SCIENCE REPORTER

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HOW ORAL CONTRACEPTIVES ACT
ROLE OF HYBRID WHEAT IN BAKING
KINDS AND USES OF POLYMERS
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LETTERS

Crossword puzzles

Sir, The crossword puzzles published in your magazine are not, strictly speaking, crossword puzzles. In a crossword, any stretch of letters when read from top to bottom or left to right should form a word. If this point is kept in mind, solvers could be more sure of what they fill in because the intercrossing of horizontal and vertical words would provide a check as to whether what is filled in is correct or not. Moreover, the subject matter of any one puzzle pertains to a very narrow field. If this could be widened, it would cater to more people.

G.S. Toor
IIT, New Delhi

Water

Sir, I thank you and the author for the excellent article, "Water—an anomalous liquid" (*S. R.* October, 1973). While dealing with the structure of water, the author writes that the small size of the H atom does not permit crowding of more than two atoms around it in any bonding situation, but in hydrazoic acid, N_3H, three nitrogen atoms are crowded around one H atom. How does he explain this?

Dr. R.C. Kapoor
Christ Church College, Kanpur

One must not conclude that three nitrogen atoms are crowding around H in hydrazoic acid, merely on the basis of its chemical formula, N_3H. The azide ion, N^-_3, is reported to be *symmetrical* and *linear*, the N—N distance being about 1.15 Å. In covalent azides such as N_3H and CH_3N_3 the symmetry is lost. In HN_3, the distance between the first and second N atoms is 1.24 Å while that between the second and third N atoms is 1.13 Å. The H—N—N bond angle is about 110°. In such covalent azides the electronic structure is a resonance hybrid.

In view of these facts it is clear that the situation described in connection with intermolecular linking in water is different from that existing in a single linear HN_3 molecule.

II

Sir, Re: "Water—an anomalous liquid " (*S.R.* October, 1973) I would like to know:

1. Why does water exhibit anomalous thermal expansion?
2. Does heavy water (D_2O) exhibit this property?

N. Rajan
Varanasi

The answer to this question is already available in the section "Pressure - volume - temperature relations" (p. 477 and in p. 479, 2nd and 3rd columns). A little more clarification is offered below for a better understanding of the problem.

Ice has a much smaller density (0.917 g/ml at 0° C) than water (0.9998 g/ml at 0° C) because of its rigid three-dimensional H-bonded network structure which includes small holes throughout the structure. This open structure of ice collapses when ice melts to give liquid water which contains much smaller clusters or ice-like groups. These smaller clusters are more densely packed in liquid water giving it a density higher than that of a giant ice molecule. For a given mass of water an increase in density means a corresponding reduction in volume. In other words, the effect of partial breaking of the H-bonded network during melting of ice is to give a smaller volume for liquid water. An increase in the temperature above the melting point brings down the number and size of even the smaller clusters present in liquid water resulting in further reduction in volume.

If this were the only effect taking place when the temperature was increased, the volume of a given mass of water would continue to decrease till no more clusters are left out. However, an increase in temperature of any system will result in an increase in the kinetic energy of the species present in the system. In view of this the clusters and single molecules present in liquid water will gain more kinetic energy with increase in temperature. Increase in kinetic energy will be manifested as increased moleculer motions, which, in turn, will make the liquid expand. Thus, this second effect tends to increase the volume of liquid water while the structure-breaking effect mentioned earlier tends to decrease it. From 0-4 °C the first effect is dominant. After 4 °C the second effect exerts a greater influence. These two opposing effects balance each other at 4 °C, the temperature of maximum density or minimum volume. Thus we see that the anomalous expansion of water is to be attributed to its structure.

2. D_2O does exhibit the property of anomalous thermal expansion. The temperature of maximum density in this case is 11.2 °C compared to 4 °C for water.

III

Sir, Re: "Water—an anomalous liquid" (*S.R.* October 1973), is there any absorption by water molecules in the visible region? If so, at what wavelengths? What about the intensity of the absorption spectrum?

Ganesh Prabhu Gurpur
Canara Junior College, Mangalore

Water does not exhibit absorption in the visible region. The large amount of colorimetric and spectrophotometric work done on aqueous solutions of coloured compounds is mainly due to transparency of water to visible radiation. Water, however, exhibits strong absorption in the infra red region (beyond 1.5 micron).

IV

Sir, The article "Water—an anomalous liquid" by P.S. Ramanathan (*S.R.* October, 1973) was interesting and useful. Methane with no power to form hydrogen bonds shows the expected very low boiling point. Its melting point, however, is about 20 °C higher than the expected value. What may be the possible explanation for this?

Are there any structural differences between the different forms of ice?

Melting point of ice-I decreases with increase in pressure whereas those of many other forms exhibit an increase with increase of pressure. What is the explanation for this?

KALIPADA DAS
Calcutta

1. It is true that the C—H link has no tendency to form hydrogen bonds except when the other groups attached to the carbon atom are of such kind as to give the hydrogen some sort of acidic character. A acetylenic C—H link, however, has been suggested to be sufficiently polar to form hydrogen bonds (A.W. Baker and G.H. Harris, *J. Am. Chem. Soc.*, **82**, 1923, 1960). CH_4 does show melting point and enthalpy of fusion values higher than the anticipated ones though the magnitude of deviation is much less compared to those exhibited by H_2O, HF, etc., in their respective series. The slightly anomalous behaviour of CH_4 in the hydride series of Group IV elements cannot be expected if only dispersion forces were operating in bonding the molecules. So far as my knowledge goes an explanation for the anomalous behaviour of methane has not been given (L. Pauling, *The Nature of the Chemical Bond and the Structure of Molecules and Crystals*", Third Edition, Oxford & IBH Publishing Co., Bombay.)

2. There are structural differences between the different forms of ice. Ordinary ice (ice I) is one of many polymorphic forms of ice. Ice II to VII are crystalline modifications formed at high pressures.

3. The derivative dT/dp (representing the variation of melting point with pressure) is given by $T\Delta V/\Delta H$, where ΔH and ΔV are the increase in enthalpy and volume at the transition point for the same quantity of substance, conveniently chosen to be one mole. Since ΔS is rarely negative, the sign of dT/dp for melting is decided by that of ΔV. It is usually positive except with water, bismuth, gallium, antimony, germanium and potassium tetrasilicate ($K_2Si_4O_9$) under ordinary pressures. With the first two, the downward trend of melting point with increase in pressure is ultimately reversed by phase transformations in the solid. As the high pressure polymorphs of ice (unlike ice I) have densities greater than that of liquid water, their melting is accompanied by a decrease in density or an increase in volume. In other words ΔV values in these cases turn out to be positive thereby giving a positive sign for dT/dp.

DR. P.S. RAMANATHAN
Scientific Officer
Analytical Chemistry Dept.
BARC, Trombay, Bombay

Electricity from oceans

Sir, I read with interest "Electricity from oceans" by Syed Ismail Ahson (*S.R.* December, 1973). The author has described only the production of electric power from the fusion of deuterium atoms, since deuterium is available in plenty in the sea water. Two more methods have been designed to produce electric power from the oceans.

As there exists a temperature gradient in the tropical seas, floating power plants employed for the purpose can produce electricity making use of the principle of thermoelectricity or by the absorption of this heat. The difference in temperature between the surface of the sea and at a depth of 500 metres is about 17°C or more.

Yet another method is by rotating the turbine wheels by tides to generate electricity. The sea water is caught at high tide and released through turbines at low tide to produce electricity. In France, a tidal power station produces about 800 million kilowatt hours of energy per year.

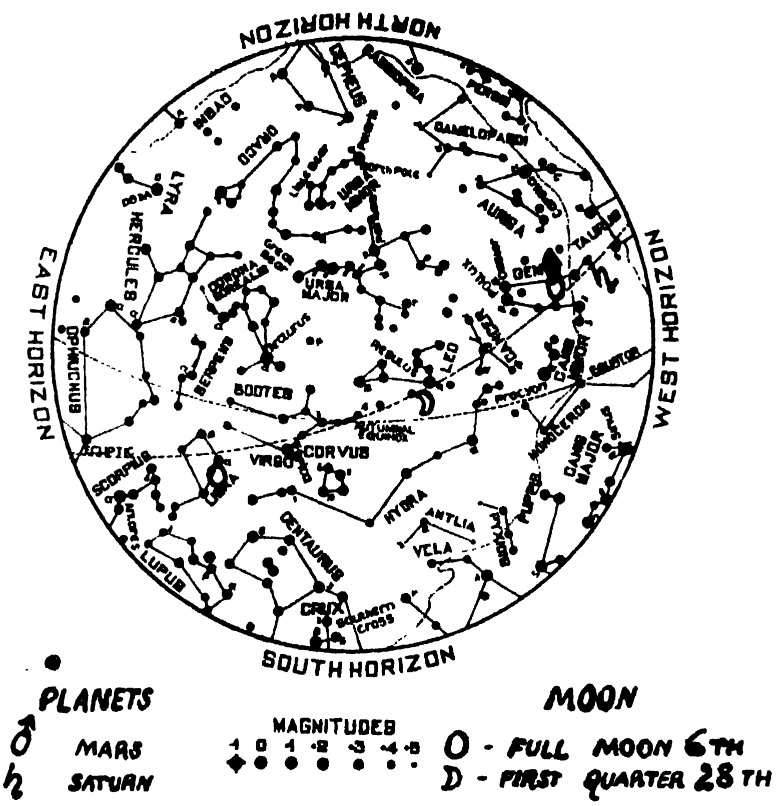
L.K. SURESH
Somwar Peth, Poona

Animals and weather

Sir, Reading S. Sengupta's experience (*S. R.* January, 1974) about birds being able to anticipate weather change, I wish to relate my own experience. The year was 1929 and the month, February. I was on a construction work near Jabalpur. I had read in *Titbits* (a weekly of England) that a bullock trying to excavate earth with its horns is a sure sign of coming rains. One morning I saw it happen. I wondered how it could rain that day, as there was no sign of clouds in the sky. But, sure enough, clouds began to gather in the afternoon and there was a heavy downpour in the evening.

D.J. JOGLEKAR
Dadar, Bombay

PLANETS AND THEIR POSITIONS — MAY 1974



The moon

FULL moon on 6th at 2.25 p.m. and new moon on 22nd at 2.04 a.m. I.S.T. The moon passes about seven degrees north of Jupiter on the 16th and the same amount north of Venus in the early hours of 19th. It passes about two degrees south of Mercury on 23rd, about half a degree south of Saturn on the 24th and four degrees south of Mars on 25th. The lunar crescent becomes first visible after the new moon day in the evening of 23rd. The moon is at apogee or fartherst from the earth on the 12th and at perigee or nearest to it on the 24th.

The planets

Mercury (Budha) is too near the sun to be visible during the first half of the month being in superior conjunction on the 4th. In the second half it reappears as an evening star and sets about an hour after sunset. It passes about seven degrees north of the star Aldebaran (*Rohini*) on the 17th. It moves from Aries (*Mesha*) to Gemini (*Mithuna*) through Taurus (*Vrisha*). Its visual magnitude varies from —1.3 to +0.3.

Venus (Sukra), a morning star, rises about two hours before sunrise during the month. It moves from Pisces (*Mina*) to Aries (*Mesha*). Its visual magnitude is about —3.6.

Mars (Mangala) visible in the evening sky, sets about one and a half hours before local midnight during the first half of the month and about two hours before it during the second half. It passes about five degrees south of the star Pollux (*Punarvasu*) on the 30th. It moves from Gemini (*Mithuna*) to Cancer (*Karkata*). Its visual magnitude is about +1.8.

Jupiter (Brihaspati) rises about two hours after local midnight during the first half of the month and about an hour after it during the second half. It is in Aquarius (*Kumbha*). Its visual magnitude is about —1.8.

Taturn (Sani), visible in the evening sky, sets about three hours after sunset during the first half of the month and about two hours after it during the second half. It is in Germini (*Mithuna*). Its visual magnitude is about +0.3.

(*Source*: Nautical Almanac Unit of the Meteorological Office, Alipore, Calcutta-27).

Kinds and Uses of Polymers

SADHAN KUMAR DE

Several factors such as molecular weight, cross-linking, and additives influence the properties of a polymeric product. Manipulating two or more of these factors can help in tailor-making a polymer with desired properties

RUBBERS, plastics, films, viscous oils, and glues are but a few representatives of polymers. They show a wide diversity of physical properties. Some are hard or soft, glassy or rubbery, brittle or tough, stiff or supple. Moreover, the same polymer can be glassy at low temperature and rubbery or even viscous liquid at a higher temperature. A given polymeric material can be made stiff or supple by proper chemical treatment. Obviously, this diversity of properties reflects difference in chemical structure of the molecules and the different ways of aggregation of the polymeric chains. Factors responsible for this difference are: molecular weight, chemical structure, glass transition temperature, crystallinity, copolymerization, cross-linking, plasticization and effects of different additives.

Molecular weight is an important factor in the determination of the properties of the polymeric materials. For any polymeric material, the properties change with the increase in the degree of polymerization. Polymers having degree of polymerization less than about ten are called telomers or oligomers. Low molecular weight compounds are generally liquids and oily at room temperature. As the degree of polymerization increases, polymers that are oils at room temperature change gradually to soft solids and then to hard solids. When the degree of polymerization reaches the order of several thousands, polymers possess properties which make them useful as elastomers, films and fibres. Table 1 shows the changes in character of polyethylene that occur with increasing molecular weight. It is interesting to note that polyethylene is a soft wax when its molecular weight is 4,000, but is a tough solid at a molecular weight of 30,000.

A simple, rapid and accurate method of determining molecular weight of a polymer is the determination of viscosity η of dilute solutions of the polymer at a number of concentrations. The method involves four steps:

(*a*) Measurement of viscosities of dilute solutions of the polymer, as well as that of the pure solvent.

Dr. De teaches chemistry at the IIT, Kharagpur

Table 1. Changes in properties of polyethylene with increase in molecular weight*

Number of (CH_2-CH_2) units	*Molecular Weight*	*Physical State of Polymer at 25 °C*
1	28	gas
6	168	liquid
35	980	grease
140	3,920	wax
250	7,000	hard wax
750	21,000	hard resin
1,350	37,800	hard resin

* From H. Hopff, *Kunstoffe*, 50, 14 (1960).

(*b*) Calculation of specific viscosity at each dilution (or concentration) *C*. (Specific viscosity is defined as follows:

$$\eta \text{ specific} = \frac{\eta \text{ solution} - \eta \text{ solvent}}{\eta \text{ solvent}}).$$

(*c*) Calculation of intrinsic viscosity (η). (The intercept in the plot of η specific/C versus C is known as intrinsic viscosity.)

(*d*) Calculation of molecular weight *M*. (The intrinsic viscosity is related to the molecular weight by the equation:

$$[\eta] = KM^{\alpha},$$

where K and α are constants for a given solvent-polymer system.)

A polymer is not like an ordinary molecule. On the contrary, it is a mixture of molecules of different sizes or weights. The molecular weight of a given polymer is determined as an average value. It varies with the method of determination. For example, some determinations depend on the number of molecules, whereas others on the weight of the individual molecules. Consequently, the molecular weights so obtained are referred to as number-average and weight-average molecular weights respectively. The molecular weight as obtained by viscosity measurements is known as viscosity-average molecular weight and it lies between the other two averages.

Number-average molecular weight ($\overline{M}_n$) can be expressed by the following relationship:

$$\overline{M}_n = \frac{\Sigma(N_iM_i)}{\Sigma N_i} = \frac{W}{N}$$

where N_i is the number of molecules with molecular weight M_i; W is the total weight and N is the total number of molecules in the sample.

In most instances, however, this expression is not used for evaluating M_n since it would require very exacting fractionation procedures which are tedious. However, the number-average molecular weight can be evaluated by using one of the colligative properties of the polymer when dissolved in a suitable solvent. Osmotic pressure is one of the colligative properties and commonly used to determine $\overline{M}_n$.

Weight-average molecular weight may be expressed mathematically as follows:

$$\overline{M}_w = \frac{\Sigma(N_iM_i^2)}{\Sigma(N_iM_i)} = \frac{\Sigma(W_iM_i)}{W}$$

where W_i is the weight of molecules with molecular weight M_i; other terms have the same significance as defined before. $\overline{M}_w$ is generally derived from light scattering experiments.

The weight-average molecular weight is always higher than the number-average. The two values become identical only when all the molecules are of the same size. Therefore, the ratio $\overline{M}_w/\overline{M}_n$ can be taken as a measure of the distribution of the molecular weights of the individual molecules. The difference in the two molecular weight averages can be illustrated by considering a polymeric mixture containing an equal number of molecules of molecular weights 50,000 and 100,000. Then,

$$\overline{M}_n = \frac{50{,}000 + 100{,}000}{2}$$

$$= 75{,}000$$

$$\overline{M}_w = \frac{(50{,}000)^2 + (100{,}000)^2}{150{,}000}$$

$$= 83{,}333$$

It should be noted that molecular weight distribution is an important factor in determining the physical properties of the polymers.

Wijga*, working with isotactic polypropylene, observed that non-brittleness is favoured by high molecular weight and low crystallinity. He concludes that a high $\overline{M}_n$ is required to avoid brittleness. Flow, however, is governed by $\overline{M}_w$. A low $\overline{M}_w$ is required for better flow. Therefore, a low ratio $\overline{M}_w/\overline{M}_n$ is required for non-brittleness and easy processing of the final polymeric product.

Glass transition temperature

When a solid polymer is heated, it shows abrupt changes in a number of properties. Fig. 1 is a hypothetical curve showing the relationship between the relative volume of the polymer and temperature. Inflections in both amorphous and crystalline polymers in the region of T_g is due to the transition from glassy state to the leathery state. T_g is known as the glass transition temperature. In the case of crystalline polymers, however, a second inflection occurs at a higher temperature in the range of T_m. Beyond T_m crystallinity cannot be detected in the polymer. T_m is known as the melting point.

The transition temperatures may be determined experimentally in a number of ways such as the use of dilatometric method and differential thermal analysis. The glass transition temperature may be defined descriptively as that temperature below which the polymer is "glass-like" and above which it is "rubber-like". In general, if a polymer has a T_g below room temperature, the material behaves as a rigid solid plastic. However, such descriptive definition is not always valid, particularly for polymers

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*P.W.O. Wijga, Paper presented at Symposium of Soc. of Chem. Ind., London, April 15-17, 1958.

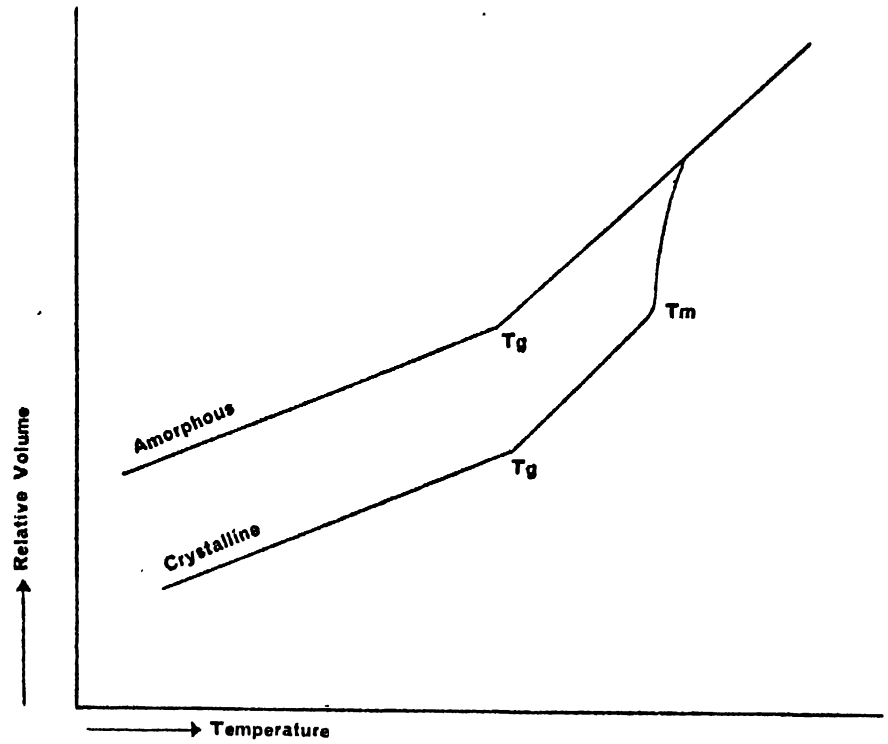


Fig. 1. Relationship between the relative volume of the polymer and temperature

having crystallinity. For example, polyethylene (a partially crystalline polymer) has a low T_G (−120°C) and this material cannot be conceived as a rubber at room temperature. For amorphous polymers, however, the descriptive terms hold fairly well. In the case of crystalline polymers, crystallites act as cross-links between the long molecular chains and are responsible for their rigidity even at T_G. In general, the crystalline polymers maintain their rigidity over a temperature span of about 90° above T_G. The percentage of crystallinity tends to decrease with increase in temperature. Then, at a certain critical temperature (T_m), all the crystallites melt and the polymer starts to flow like a liquid. Consequently, crystalline polymers have higher temperatures of liquid flow than amorphous polymers. If two varieties of the same polymer are prepared, one with low crystallinity and the other with high crystallinity, it is observed that the temperature interval between the glassy and liquid flow states is wider in the more crystalline variety. This is because although both types have the same glass transition temperature, the more crystalline variety has a higher temperature of liquid flow.

Each amorphous polymer has its own characteristic glass transition temperature. This depends on the chemical structure and the mode of aggregations of the molecules. For example, rubber passes from the brittle glassy state to the flexible state at a comparatively low temperature because its molecules are inherently pliable, rotating freely around each carbon link, and also because the molecules are weakly held together. On the other hand, a polymer made up of inherently stiff molecules or molecules strongly held together at different sites along the chains will allow the glassy state to exist at a relatively high temperature. It is now understandable why T_G of polyisoprene (rubber) is around −73 °C, while that of polymethacrylate is around +3°C.

Theoretically, a polymer in the glassy state can be described as a "supercooled liquid" (as can glass itself). Its long chain molecules lie quiet, frozen in their random configurations. As the polymeric material is warmed, the long chain segments abandon their frozen state and begin to move. Sometimes the segments are restrained in their movement by crosslinks and sites of entanglement between the chains. As the transition temperature range is approached, the short segments start moving and the polymer attains the leathery state, that is, flexible but tough and resilient. With increase in temperature it becomes less tough and more pliable, and finally enters into a rubbery state. At this stage the entire free lengths of the molecules between cross-links and centres of entanglement are in rapid movement, twisting and rippling in all directions.

When the rubbery polymer is heated to a sufficiently high temperature, it yields its shape and begins to flow like a viscous liquid. At this stage entire molecules flow past one another.

Fig. 2 shows the temperature dependence of polymer elasticity and the four types of behaviour of polymers (i.e., glassy, leathery, rubbery and viscous liquid). The modulus of elasticity may be measured by applying a tensile stress to a specimen and measuring the fractional change in length (strain). At low temperature the polymer is rigid and glassy and the modulus of elasticity (E) is not too different from steel. As the temperature is raised, the modulus goes through a sudden change, in which the polymer has a leathery type of behaviour. With further increase in temperature the polymer becomes rubbery. This state is characterized by a modulus, E, of about 10^7 dyne/cm^2. When the polymer is heated beyond the rubbery state, it becomes

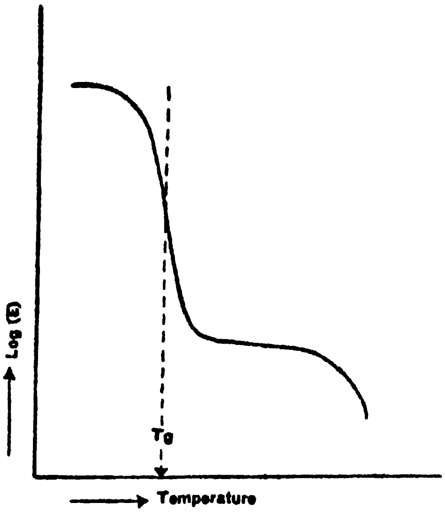


Fig. 2. Temperature dependence of polymer elasticity

molten and behaves like a viscous liquid.

Table 2 lists a number of polymers with their glass transition temperatures. Values of T_G range[5] from −123 °C for silicone to 208 °C for polyvinyl carbazole. One of the important factors in determining the value of T_G is the flexibility of the polymer chain. Ether linkages (*-O-*) such as found in silicones are extremely flexible and produce a large lowering of T_G.

Crystallinity

In case of crystalline polymers molecular segments in the amorphous part of the polymer become free to move at glass transition temperatures. However, unlike amorphous polymers, it does not become leathery or rubbery at T_G. It loses its brittleness, but not its rigidity which depends on the degree of crystallinity. For example, polyethylene with 70 per cent crystallinity is more rigid than a 45 per cent crystalline variety. However, some percentage of amorphous structure is needed for impact strength. The amorphous regions of the polymer provide flexibility to absorb the shock of impact, while the crystalline regions (or crystallites) provide strength.

It should be recognized that the word "crystalline" as used in the above discussion does not carry exactly the same meaning as used with crystalline sodium chloride. The nature of crystalline state of the polymers is not clearly understood. However, a working idea can be obtained if the long chain molecules are considered to exist with each other in the following two ways: (a) crystalline state is like a bundle of uncooked spaghetti when the chains are more or less regularly arranged; (b) amorphous state is characterized by its randomness, as in a bowl of cooked spaghetti. The act of crystallization is then the process of converting random amorphous chains into regular crystalline regions. Because of regularity in the arrangement of the polymeric chains, crystalline polymers can be efficiently packed into a region forming a zone of higher density. In fact, crystallinity can be followed by measuring the density of the polymer; the higher the density the greater is the degree of crystallinity.

Crystallinity can occur when the backbone chain orients itself in a regular fashion and side groups are either small, absent or regularly arranged so that packing can occur. The more recent stereospecific catalyst method of polymerization induces regular chains without branching, producing crystalline polymers. Crystallites can also be made to form by cooling the polymer from the melting point or by stretching. The same molecules that are involved in a crystalline region may also extend through several amorphous and other crystalline regions. Since the long chains tend to pass through several crystallites, crystallization is often hindered, and this is one reason why the higher molecular weight crystalline polymers cannot achieve as high a crystallinity as the lower molecular weight ones. Between the several crystallites there exist amorphous regions having the same properties as typical amorphous polymers.

Examples of crystalline polymers are teflon, nylon, polyethylene and polypropylene. Crystallization causes dramatic changes in the property of the material. As the crystallinity increases, the material becomes harder, less flexible, less transparent and has a higher melting point. Crystalline regions are generally very resistant to penetrating molecules and molecules pass only through the amorphous region.

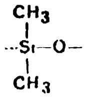
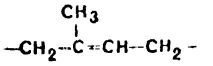
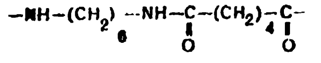
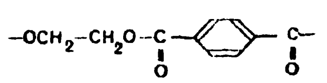
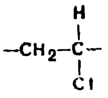
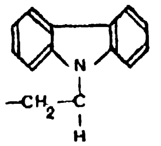
In crystalline polymers the molecules may be unoriented (arranged in random ways) or highly oriented. Cotton, wool and silk are examples of naturally occurring oriented polymers. The orientation gives these substances great tensile strength and makes them useful as fibers. The same kind of structure gives synthetic fibers their even greater strength. Machines spin these fibers by extruding the polymers as threads and stretching the threads in a particular direction to orient the molecules. Nylon and polyester are examples of synthetic fibers.

Other factors

Cross-linking. The tendency to liquid flow of polymers can be entirely suppressed if one chain is cross-linked with another. Cross-linking may be achieved by the use of a chemical reagent or by physical means, such as radiation. Due to cross-linking, the sliding of one chain past another and loosening of entanglements are no longer possible. However, motion of chain segments is still possible and elasticity is imparted to the sample. A very high degree of cross-linking, on the other hand, produces a structure that makes no transition from the glassy state and remains rigid and hard at all temperatures until actual chemical decomposition occurs. This is the structure of the so-called thermosetting plastics, e.g., Bakelite.

Vulcanization of rubber is an

Table 2. Glass transition temperatures of polymers

Polymer	Repeat Unit	T_G(°C)
Polydimethyl silicone (silicone)	 $-\overset{CH_3}{\overset{\vert}{\underset{CH_3}{\underset{\vert}{Si}}}}-O-$	−123
Polyethylene	$-CH_2-CH_2-$	−120
Polyisoprene (rubber)	 $-CH_2-\overset{CH_3}{\overset{\vert}{C}}=CH-CH_2-$	− 73
Polyhexamethylene adipate (nylon 6,6)	 $-NH-(CH_2)_6-NH-\underset{O}{\underset{\Vert}{C}}-(CH_2)_4-\underset{O}{\underset{\Vert}{C}}-$	90
Polyethylene terephthalate (polyester)		69
Polyvinyl chloride	 $-CH_2-\overset{H}{\overset{\vert}{\underset{Cl}{\underset{\vert}{C}}}}-$	87
Polytetrafluoro ethylene	$-CF_2-CF_2-$	126
Polyvinyl carbazole		208

example of introducing cross-links in the polymeric molecules. Vulcanization can be achieved chemically (e.g., by sulfur or sulfur compounds). The same effect can be achieved in rubber and other polymers by high-energy ionizing radiation which knocks out hydrogens and cross-links the chains in direct carbon-carbon bonds. In rubber, where extensibility is desired, vulcanization process is controlled so that one cross-link is established for about every two hundred atoms along the chain.

Cross-linking can increase the melt temperature of the polymer to a considerable extent. For example, proper cross-linking of polyethylene may raise the melting point by 100 to 200°C. Cross-linking may also decrease the swelling tendency of a polymer when in contact with a solvent having high affinity for the material. In some cases cross-linking can also affect the diffusion and permeation of small molecules through the matrix of the polymeric material.

Too much of cross-linking sometimes may lead to deterioration of the polymeric material. This has been noted when certain types of polystyrene and polypropylene syringes were sterilized by irradiation methods. The extent of cross-linking depends on the exposure time and level of radiation induced. This leads to a brittle material which breaks easily when pressure is exerted upon it.

Copolymerization. Copolymerization is a method of modifying polymer properties. For example, when ethylene is polymerized a crystalline polymer results. The same is true for polypropylene. However, copolymerization of the two destroys the crystallinity because of randomness along the chain. The resulting copolymer serves as a rubbery material.

Vinyl chloride-vinyl acetate and vinyl chloride-vinylidine chloride copolymers make excellent fibers for use in surgery. Polybutadiene, which has a rather low glass transition temperature of —70°C, can be copolymerized with styrene to produce a rubbery material with T_G around −45°C. The resulting copolymer is more useful in high temperature applications.

In addition to changing mechanical properties, copolymerization can affect changes in such properties as resistance to solvent attack, diffusion and permeation of small molecules through the polymer, and electrical insulation.

Plasticization. One method of lowering glass transition temperature of polymers is to add selective low molecular weight compounds known as plasticizers. The plasticizers are believed to be not chemically bound with the polymer. They dissolve in the polymer matrix and act as "lubricants" between the different long chain segments. This results in facilitating the sliding of one chain past another and in loosening of entanglement and thereby lowering T_G.

The best examples of the use of plasticizers is in the large number of flexible polyvinyl chloride devices used in medical practice. Without the addition of the plasticizer the plastic would be extremely rigid and often could not be used for the intended purposes at all.

Filler. Natural rubber, which is amorphous at room temperature, becomes oriented and crystalline when stretched. This is responsible

(*Continued on page 177*)

STORY OF CULTURED PEARLS

NIRMAL K. THAKUR

Once exclusive privilege of royal personage, pearls today adorn neck-lines of millions of ladies all over the world. The story of pearl culture is as fascinating as pearls themselves

PEARLS, since antiqiuty, have maintained their reputation as one of the rarest 'gemstones'. They were so rare that many believed them, in fits of imagination, to be 'tears of the moon'. But the reality is far from these poetic flights. As it came to be known later, pearls are formed when some alien body such as a sand grain, a small broken twig of seaweed, or a small insect accidentally enters the body of an oyster and happens to cling to a part of its mantle. Mantle of the oyster secretes nacre which starts wrapping around this intruder in an act of self-defence. In due course, the deposition of nacre over the foreign body grows to a considerable size and a pearl is formed. The secretory material is actually the same shining substance that forms the shining inner surface of the oyster shell. Hence pearl is not a 'gemstone' in true sense but an organic substance like corals, tortoise-shells and ivory.

Pearl has been an object of rare occurrence because its formation depends upon the accidental intrusion of a foreign particle in the body of an oyster. Such intrusions are not frequent in nature. Japanese researchers, instead of waiting for such rare occurrences, invented methods to simulate the natural phenomenon and succeeded in producing cultured pearls. The appearence of cultured pearls in the world market had initially created disputes whether they were 'real' or 'artificial'. But studies made by scientists have now convinced men that cultured pearls are composed of exactly the same substance as natural pearls. They differ only in the nature of the initial irritant. While in natural pearls the irritant may be a sand grain or a parasitic insect or anything else, in cultured pearls it is specially made polished spherical beads cut from good molluscan shells.

History

Pearls, or 'Shinju' as they are called in Japanese, are perhaps the most characteristic of all the products of Japan. Their excellence can in a large measure be traced to a man named Kokichi Mikimoto, often referred to as the father of pearl industry in Japan.

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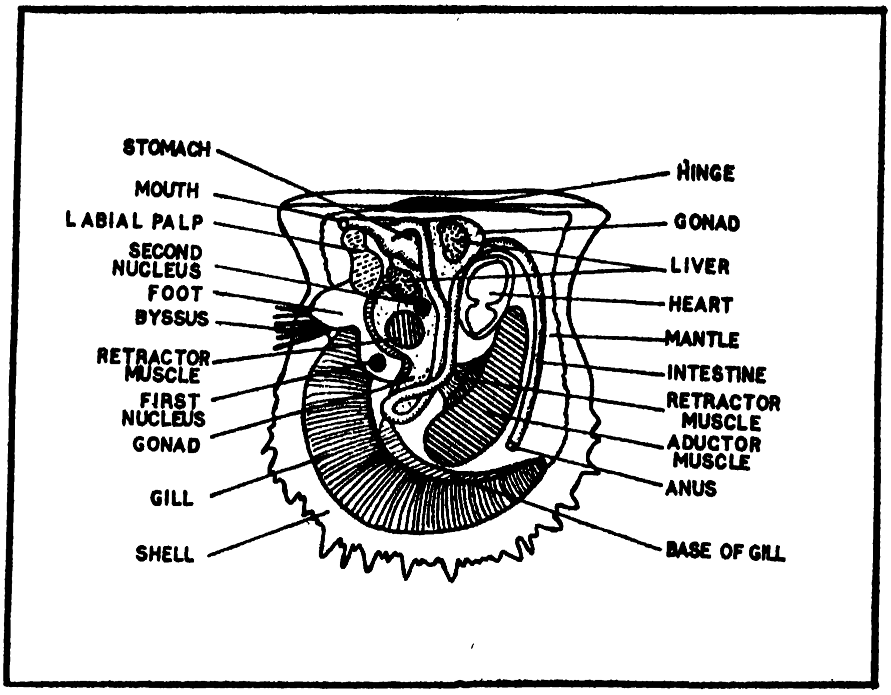

Fig. 1. Anatomic diagram of a pearl oyster showing the location of 1st and 2nd nucleus

Kokichi Mikimoto (1858-1954) hailed from Toba, a small town in Mie Prefecture, on the south-central coast of Honshu island. He was the eldest of the eleven children of a noodle vendor. In his boyhood he worked in his father's trade as a green grocer. Later on, he moved to Tokyo-Yokohama district where he began dealing in marine products. It was in 1890 that the fourth Annual Domestic Industrial Promotion Exposition was held in Tokyo where amidst many exhibits Mikimoto saw tiny beads of natural pearl being sold at exorbitant price. An accompanying exhibit displayed how pearls are formed in nature. While watching this exhibit, an idea clicked into his mind that he might gain fame and fortune by encouraging the oysters to do what they do in nature. Dr. Keikichi Mizukuri of Tokyo University, a judge at the exposition, gave Mikimoto a resume of the subject and encouraged to put his idea into effect.

Young Mikimoto resolved to start his experiments in the autumn of that very year. He established his pearl farm at Shimenoura in Ago bay and his experimental station on a small island off Toba in September, 1890. There he groped blindly in the field of oyster culture trying to find out the answer to the riddle of pearl formation. Two discouraging years passed without any results. In the third year a disastrous red tide ('Akashio' in Japanese) swept into the bay and wiped out all his experimental oysters except a batch which was protected in an isolated cove. Summer brought the time to examine this last remaining batch. With little hope Kokichi and his wife Ume spent six desperate days opening the oyster shells and as usual found nothing therein. Then on July 11, 1893, a day that Mikimoto never forgot, Ume opened a shell. There imbedded lay an irridescent semispherical blister pearl glistening in the sun! Excited, laughing and crying at the same time, both feverishly scrambled after the remaining oysters. They yielded four more opalescent treasures. Though far from perfect pearls, as they were not completely round, the pieces were nevertheless rare and valuable. Hurrying home, the Mikimotos placed the shining gems on the family altar and thanked God for making their dream come true. In January, 1896, the first patent in Japan on pearl culture was made in his name.

Unfortunately, the pearls produced by Mikimoto were only of the blister or half-pearl variety and were cheaper than the natural pearls of the same kind. What Mikimoto had not been able to bring about was the second step in that natural process, namely, production of a spherical pearl. Efforts to produce perfectly round cultured pearl however continued. It is said that Tatsuhei Mise (1880-1924) of Matoya, Mie Prefecture, who was a carpenter by profession became interested in pearl culture and began working on an idea that occurred to him. He produced the first spherical pearl at his home at Watakanoshima in Matoya bay. According to records, probably he was the first person to develop a spherical cultured pearl. The exact date, however, could not be established, but it was before 1904, because in that year it is said he showed his cultured spherical pearls to Dr. Kishinoue, a leader among Japanese marine scientists. Mise could obtain a patent of his method on April 27, 1907, apparently the first patent issued on the culture of spherical pearls.

Though the works of Mikimoto and Mise were of great significance, the method used today throughout Japan to produce spherical pearl is the one invented by Tokichi Nishikawa, a government scientist employed at the Misaki Marine Biological Laboratory of Tokyo Imperial University (present Tokyo University). Nishikawa, in fact, was the first person to produce a spherical pearl by scientific method with the finished products resulting from planned experiments. Nishikawa died at an early age of 35 on June 22,

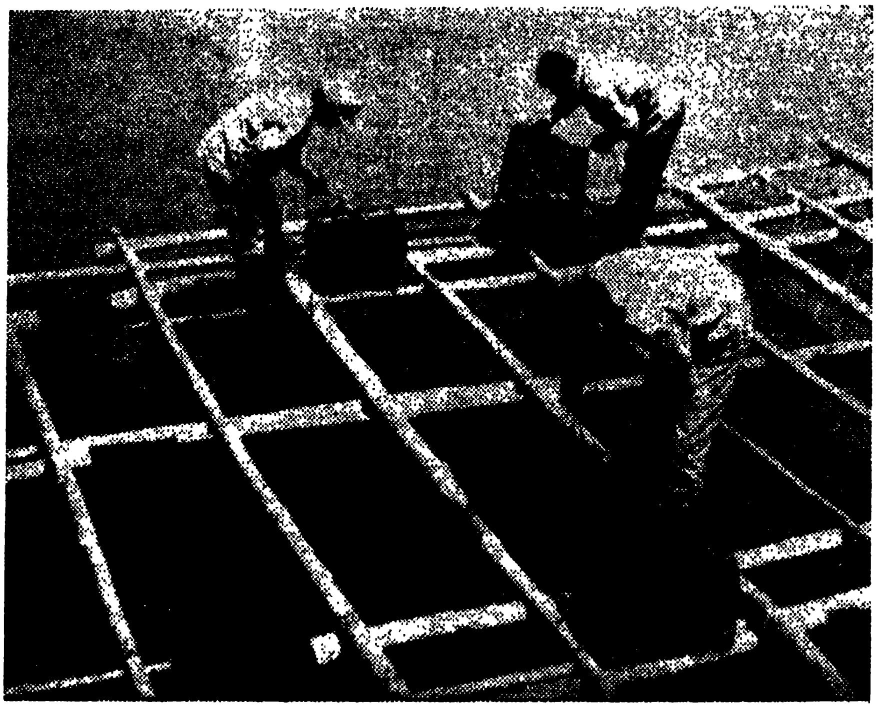

Fig. 2. Periodical inspection of caged oysters

1909. His untimely death however did not halt the work, for his followers further verified his method and put it on an industrial scale. Mikimoto also continued his experiments. Working hard with the oysters himself he finally achieved the goal and patented his method in 1919.

Mother-of-pearl

Oysters of right type are the most important prerequisite for production of pearls. Although many bivalved mollusks can produce pearls under the stimulus of an irritant and suitable environmental conditions, production of quality pearls is confined to a relatively small group of species. Some of the most common ones are: Japanese pearl oyster (*Pinctada martensii*); Black-lipped pearl oyster (*P. margaritifera*); Silver-lipped pearl oyster (*P. maxima*); and Black winged pearl oyster (*Pteria penguin*). The Japanese pearl oyster (*P. martensii*) is by far the most important species in the pearl culture industry. They are smaller and produce the finest though not the largest pearls. *P. margaritifera* and *P. maxima* are the giant species of the genus and produce pearls of the bigger size, but they are somewhat inferior in quality because of the coarseness of their nacre. *Pteria penguin* are shy type and less hardy than other oysters. However, blister pearls produced from this oyster are of the highest calibre and, if perfectly round ones could be developed, they are as precious as diamonds.

Collection. Collection of pearl oysters from ocean floor is done by women divers called 'Ama', meaning 'girls of the sea'. These girls from their early childhood are trained to dive for sea-shells and seaweeds. They wear tight white cotton suits and caps and cyclops goggles for better undersea vision. When diving in water less than 5 m deep, each diver is provided with a small hand net. A large wooden bucket remains attached to the diver's waist by a stout cord. The oysters collected from the bottom are brought to the surface in the hand net and deposited into the floating bucket. Each dive, depending upon the skill and experience of the diver, lasts for half a minute to over one minute and the catch averages from 1-10 oysters/dive. In deeper waters, the diver operates directly from the side of a boat. While submerging, the diver takes a deep breath and grasps a heavy weight supported on a rope which remains connected to a pully mounted on the gunwale of the operating boat. The weight helps diver sink to the bottom quickly. A rope remains fastened to the diver's waist through which the operating boatman hauls the diver up to the surface after receiving signal from her. Between plunges, the girls keep whistling sharp by pursing their lips. It is called 'isobue' (a whistle of the beaches) or 'isonageki' (the solitarity of the beaches). It is said that whistling increases the lung power.

The vertical distribution of the pearl oyster ranges from 1-10 m. In waters exceeding 8 m in depth dives last for 20-25 seconds. All deep diving is done at low tide. As the tide rises divers move to shallow water. At the close of each diving period the collected oysters are taken to the shore base where oysters of various age groups are sorted out. Two year old oysters are purchased by the fishing associations who sow them again in shallow waters for future use. Three and four year-old ones are taken to the farms and distributed over moderately rough bottom in shallow waters where they are kept undisturbed until April-May of the following year, then picked up and brought to the laboratory for nucleus insertion.

Raising oysters from culture spats has gained tremendous popularity since Mikimoto discovered the method to catch drifting oyster eggs and incubate them artificially. Mikimoto's method, in fact, is a boon in the field of pearl culture industry, for it solves a big problem of obtaining oysters for pearl culture. That the free swimming spat of pearl oyster has a marked tendency to avoid light led Mikimoto to devise a special type of spat collector which consists of a cage (84 x 54 x 20 cm) formed by covering a heavy wire frame with a 2 cm wire mesh. The cage is dipped into hot coal tar as a measure against corrosion. These cages are then dipped into a thin sand-cement mixture. It provides a rough surface to the cage to which the free swimming spat gets easily adhered. Black painted boards are fastened to the sides and bottom of the cage as lures to the nonphototrophic spats. These cages as suspended at a depth of 6 m from floating rafts anchored in areas where spats are copiously available. Cages are set out in early July and remain there until late November. By this time the young oysters are about 1.5 cm long and are ready to be removed and transferred to the rearing cages. The average range of spat setting on a cage is from 7,000 to 10,000 individuals.

The rearing cages resemble the collecting cages except in that they remain divided into 4-6 compartments and lack the diagonal subdivisions. They remain covered with a wire mesh or cotton netting. In these cages young oysters remain well protected against their natural enemies such as octopus, eel, devil fish, etc. Stocked cages are either put at the sea bottom or suspended from the rafts and kept until following June or July. The oysters which are now one year old are sown in the water 3-5 m deep over a fairly rough bottom. Here they are kept undisturbed for a period of two years. During June to August of the third year, the oysters are collected by divers, cleaned and then placed in culture cages again for a period of ten days. These ten days actually allow oysters to recover from the shock of excessive handling and make them physiologically adjusted to the shallow water conditions of the sea. Oysters are finally picked up for nucleus insertion.

Nucleus insertion

Although there are quite a few ways of inserting nucleus into the body of the oysters, the one used throughout Japan today is Tokichi Nishikawa's method which runs on these lines: a piece of the mantle of a living oyster is cut off and is inserted together with a suitable nucleus into the living tissue of another oyster. The process involves making oysters fit for operation; preparing the pieces of mantle called graft tissue; preparation of suitable nucleus; and the final nucleus insertion operation.

The oysters selected for operation must be strong and healthy enough to withstand the shock of nucleus insertion. It is said that oysters withstand the shock of operation best after they have rid their bodies of sperm and eggs. For this, oysters before operation are alternately dipped into colder and warmer depths of the sea. Unable to take this shock, males explosively ejaculate their sperm and females their eggs. When one oyster starts doing so, the rest follow.

In order to perform the operation oysters are induced to open their shells by putting them under stress of suffocation for a short while. In the course of suffocation, when oysters begin to gape, a bamboo peg is inserted between the open space so that it may not shut again. Under no circumstance should the oyster remain agape for more than two hours before the operation. That way oysters are fatigued and are not fit to withstand the shock of operation. Experienced technicians hardly keep them agape for more than 20 minutes before the nucleus is inserted.

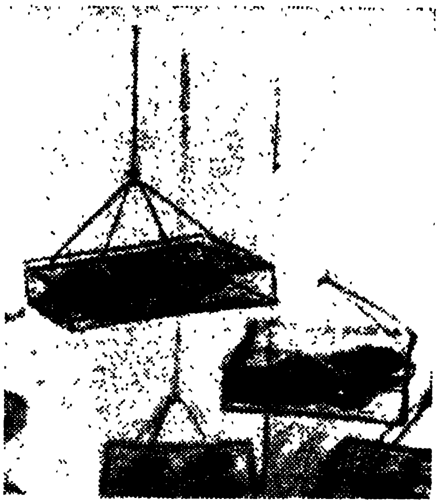

Fig. 3. Nucleated pearl oysters in cages suspended in sea water

Preparation of graft tissue is done with extreme care and precision. It is prepared from the frilled mantle edge of a living healthy oyster which has proved its merit by secreting a beautiful nacre layer inside its shell. The selected oyster is opened carefully with a sharp knife and a strip of about 7 cm long and 3/4 cm wide is cut from the edge of the mantle. It is smoothed out carefully on a wet graft trimming block and the adhering slime or mucous is wiped off with a wet sponge. The thickened outer edge of the mantle is cut away with a sharp scalpel. The remaining tissue is trimmed to the size of a 2-3 cm long narrow strip which is then cut transversally into tiny squares, the size of which is determined by the size of the nucleus to be used. If kept in clean sea water under moderate temperatures (17-22° C), the graft tissue can survive for about two hours. Since the nacre-producing cells in the mantle remain located in its outer surface, the outer and inner surfaces of the prepared tiny graft tissue must be definitely known because it is the outer surface which has to be kept in contact with the nucleus.

Although a pearl may be formed around almost any small object as a nucleus, research has proved that a calcareous nucleus is the best for the purpose. Nacre is deposited most satisfactorily over a calcareous substance. Most of the nuclei, therefore, are made from the shells of freshwater mollusks having heavy

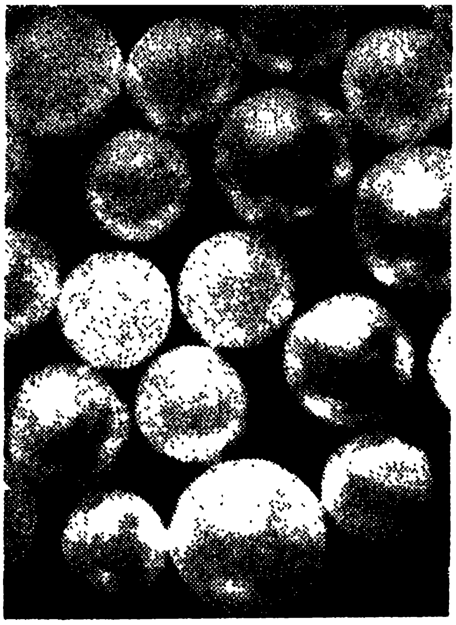

Fig. 4. A sample of cultured pearls

solid shells. Japan, unfortunately, has no such mollusks and therefore has to depend upon the United States where in Mississippi river such types of mollusks, viz., pig-toe or nigger-head mussels, are available in plenty.

The operation is performed through the gape between the shells while the oyster remains fixed in desk clamp with the right valve facing upward. Mantle folds are smoothed back exposing the foot and the main body mass. An incision is made into the epithelium of foot and a slender channel is made into the main mass of the tissue. A piece of the graft tissue is pushed down into the channel at the point selected as the bed for nucleus. The nucleus is then inserted in the channel to lie right above the graft tissue. The foot mass is then gently smoothed. By doing so the mucus helps to close the wound. Peg is now removed and the oyster returned to the holding tray.

For insertion of a second nucleus in the same oyster, operation is performed from the left side this time and insertion is done in the gonadal tissue. Insertion of a third nucleus is rarely tried. The task of inserting nucleus is mostly done by young girls who are called 'Tamaire-san' which in Japanese means, 'Miss nucleus pusher'. These girls can operate as many as 25-40 oysters/hour. After the operation is over, oysters are placed into cages and suspended into sea from the floating rafts to a depth of 2-3m for about a week or so to give them time to recover from the shock of operation. Oysters are then examined and dead ones are removed. Often the shock of operation causes many oysters to cast out the inserted nuclei. To detect which oysters in the whole lot have done that was not possible until recently. Now-a-days x-ray photography helps such detections.

And now the pearls

The cages containing nucleated oysters are suspended from the permanent culture rafts at a depth of 2-3 m. Each raft supports 60 cages containing in all a total of 3000-3600 oysters. Except for periodic cleaning and inspection, cages are kept undisturbed for a period of 3-6 years.

In theory, the process of pearl culture may sound easy but it is not so in practice. During the period of growth, culturists have tough time to protect their oysters from enemies, viz., the lethal cold water; low salinity caused by heavy rains; a red tide; growing barnacles, mosses, seaweeds, etc. With careful protection from various foes, pearl oysters thrive on planktonic diet naturally occurring in the bay. After a period of 3-6 years, the oysters are taken out from the sea and cultured pearls are brought into the world market.

Cultured pearls are formed in different colours depending upon the colour of the shell. Colours may be white, pink, yellow, grey or black. In shapes they may be round, oval or baroque. A pearl which is perfectly spherical, large in diameter, pink in colour, unmarred on its surface and having an exquisite lusture is regarded as the best.

Further reading

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2. Anon, *A story of the pearl, Mikimoto cultured pearl,* pamphlet issued by the office of the Mikimoto Pearl Island, Toba, Mie Prefecture, Japan.
3. Deena and Clark Blake, *Mikimoto the Pearl King,* pamphlet issued by the office of the Mikimoto Pearl Island, Toba, Mie Prefecture, Japan.
4. Sakikawa, N. *Gemstones* Hoikusha Publishing Co. Ltd., Osaka, Japan.

MITOCHONDRIA

Y. C. AWASTHI

The efficiency of a 'mitochondrial engine' is more than twice that of the most sophisticated man-made heat engine

Introduction

ONE of the most marvellous examples of nature's bio-engineering skill is the tiny cell which is the unit of all living beings right from amoeba to highly evolved mammals. Enveloped in a membrane, the cell embodies various sub-cellular organelles suspended in cytoplasm and these organelles carry out various life processes with the maximal efficiency.

There are long thread or rod-shaped bodies called mitochondria which provide engery to the cell and could be termed 'biological power packs' of the cell. Though functions of other sub-cellular particles like the microsomes, endoplasmic reticulum, lysosomes, ribosomes and golgi apparatus are not fully demarcated, it is clear that there exists a remarkable division of labour within the cell factory among its various units.

Of all sub-cellular organelles, perhaps the structure and functions of mitochondria have been studied most exhaustively. Mitochondria (*mitos*, in Greek, means thread) are tiny thread or rod-shaped bodies varying both in shape and size (0.3-0.7 micron in diameter and 1-5 micron in length). They are usually scattered throughout the cytoplasm in cells of almost all organs but in some type of cells they are highly localized. Thus in the mid-piece of a mammalian spermatozoon the mitochondria are tightly bound end to end around the central bundle of flagella filaments (axonema) to form a triple helix. They are also in close apposition with the plasma membrane probably to minimize the direct contact with cytoplasm.

Structure

The morphology of a mitochondrion (Figs. 1& 2) could be easily understood by imagining two membranous baloons, one of which is contained within the other and the two are separated by intercristal space or matrix. The inner membrane contains numerous inner foldings called the cristae. Electron microscopic studies with intact mitochondria as well as with the cristae fractions reveal fine structures in cristae called elementary particles which are of about 90Å diameter—'head pieces' or 'knobs' attached to the membranes with cylindrical stalks. Though there are as yet no conclusive evidences for pin-pointing the sites of various enzymes within mitochondrial compartments, it is gener-

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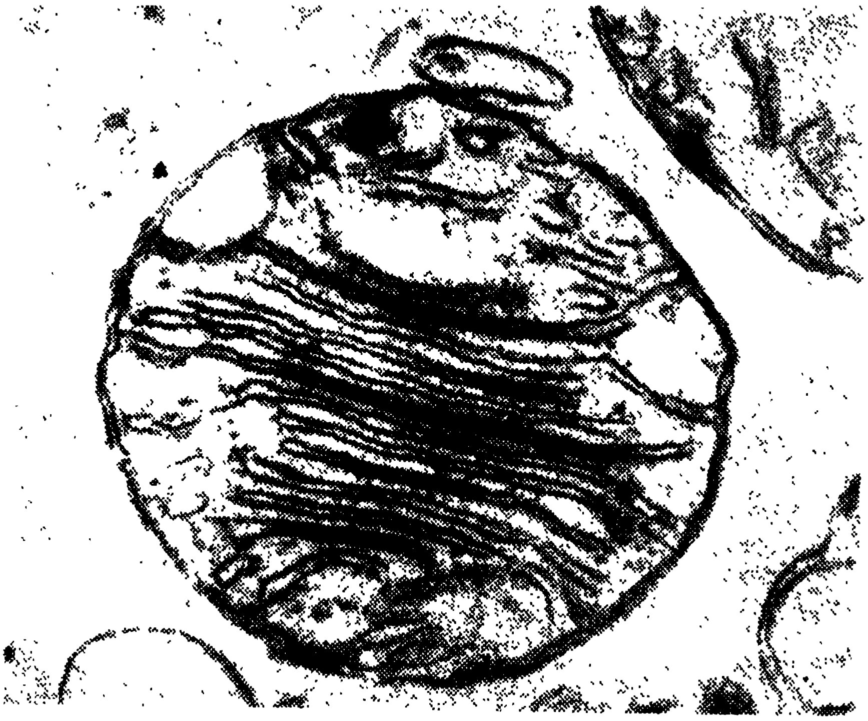

Fig. 1. **Electronic micrograph of a thin section of beef heart mitochondria (Magnification × 90,000)**

ally believed that Krebs enzymes and various other ancilliary cycle enzymes are mainly located in the matrix and the outer membrane. The components of 'electron transport chain' or 'respiratory enzymes' responsible for uptake of molecular oxygen, and factors responsible for trapping the energy evolved during respiration in the form of high energy phosphate bonds, are located in the inner membranes and are designated as Electron Transport Particles (ETP).

Though mitochondria from different sources may differ widely as to their ancilliary enzymatic capabilities, their basic function of providing energy to the cell is universal. The mitochondrion catalyzes complete combustion of pyruvate (formed mainly during carbohydrate metabolism) and the energy derived from the oxidation is conserved in the form of high-energy phosphate bonds serving as power reservoirs for the energy requirement of the cell. The main chemical constituent amongst these energy reservoirs is adenosine triphosphate (ATP).

Sun—the source of biological energy

Mitochondrion is responsible for the supply of biological energy needed for the life process. As we know, energy can neither be created nor destroyed but can only be transformed. The energy generated by the mitochondria in the form of high-energy phosphate bonds (ATP) must also originate from some source. All biological energy is derived from the sun. Two intermediate steps in converting solar energy into biological energy (Fig. 3) needed for cellular functions are carried out by chloroplasts of green plant cells and mitochondria of plants as well as of animals which eat these green plants. Chloroplasts in green plant cells absorb solar energy and form carbohydrates from CO_2 and H_2O by a complicated process called photosynthesis. Carbohydrates which are energy rich compounds are then oxidized or 'burned' as fuel by the mitochondria of plant or animal cells to liberate energy and this energy is conserved in the form of energy rich phosphate bonds (ATP) and made available for cellular work. Since instantaneous burning of glucose (a carbohydrate) would suddenly evolve high amounts of energy which could be dangerous to the cell, the process of oxidation (burning) is carried out gradually in several steps so that minimum energy is lost as heat and most of it is conserved as useful energy. Mitochondria play the most significant role in this process and hence are called 'biological power-houses'.

Since details of photosynthesis do not fall within the scope of this article let us consider how solar energy conserved by photosynthesis in the form of energy-rich carbohydrates is converted into readily available energy (ATP) for cellular work. First the glucose molecule is anaerobically (in the absence of

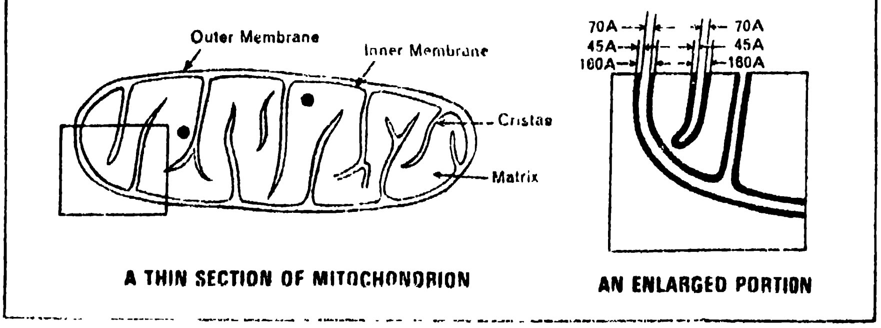

Fig. 2 . **Diagrammatic representation of a section of beef heart mitochondria** oxygen) broken down to 3 carbon atom moiety, i.e., pyruvic acid with the release of some energy which is trapped as ATP. This anaerobic breakdown of glucose (6 carbon atoms) to pyruvic acid (3 carbon atoms) does not take place inside mitochondria but bulk supply of mitochondrial fuel comes through this mechanism in the form of pyruvic acid. The overall reaction of anaerobic cleavage of glucose to pyruvic acid could be represented as follows:

$$C_3H_{12}O_6 + 2\ ADP + 2\ iP + 2\ NAD \longrightarrow 2CH_3CO\ COOH + 2\ ATP + 2\ NADH$$

Thus when a 6 carbon moiety of glucose is broken down to 3 carbon moiety, i.e., pyruvic acid, the energy liberated during breakdown of glucose is utilized to form two molecules of ATP with the help of ADP (Adenosine diphosphate) and inorganic phosphate (iP). Also during the overall process, two molecules of coenzyme I, i.e., nicotinamide adenine dinucleotide (NAD) are reduced to form NADH. This NADH also acts as the source of energy when it is oxidized in mitochondria to NAD and the energy liberated is again utilized for synthesis of ATP.

Pyruvate oxidation

The overall oxidation of pyruvate, which is carried out within mitochondrion, can be divided into three steps which are carried out simultaneously and in a continuous process. These steps are: (i) Krebs or citric acid cycle, (ii) mitochondrial electron transport, and (iii) oxidative phosphorylation. At present, first and second steps of the process are fairly well understood but the mechanism of oxidative phosphorylation, i.e., formation of ATP from ADP and inorganic phosphate during oxidation of NADH to NAD in mitochondrial electron transport is not understood as yet. However, various steps in which ATP is formed are now almost certain.

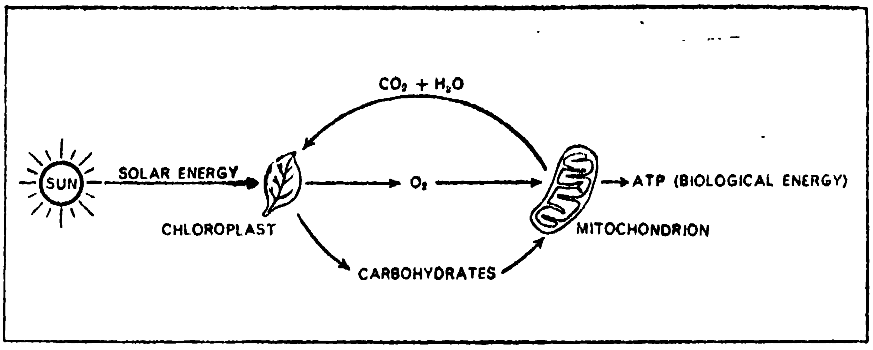

Fig. 3. Cycle showing conversion of solar energy into biological energy

Fig. 4 illustrates complete oxidation of pyruvate in mitochondria.

Krebs cycle. In presence of free oxygen, pyruvic acid formed during glycolysis is injected into another enzyme sequence which takes place in mitochondria and is known as Krebs cycle in honour of its inventor Sir Hans Krebs. The three carbon moiety pyruvic acid is first oxidized to form two carbon acetyl groups releasing CO_2, electrons and protons. Two electrons and two protons are accepted by NAD to form NADH. Simultaneously the acetyl group is linked by a high energy bond to a compound known as coenzyme A (Co-A). Acetyl group linked with Co-A is called acetyl-coenzyme A or 'active acetate'. This is the principal form in which substances can enter Krebs cycle for their final oxidation to carbon dioxide and water. In the first step of the Krebs cycle (Fig. 3) acetyl group of acetyl Co-A combines with oxaloacetic acid (4 carbon atoms) to give citric acid (6 carbon atoms). Through a series of enzymatic reactions, oxaloacetic acid is reformed in the last, with the net outcome of oxidation of 2 carbon atoms of acetate to carbon dioxide and water. Thus at the end of each round of the cycle an acetate moiety is oxidized to CO_2 and H_2O and oxaloacetic acid is made available to act as a carrier for the next acetate group to the Krebs cycle. Energy released during the net oxidation of each acetyl group is trapped and stored as ATP molecules. Also, during this cycle 4 pairs of electrons are removed and accepted by NAD and FAD (flavin adenine dinucleotide). Thus during one full round of cycle one acetyl group is oxidized to form CO_2 and H_2O; one molecule of ATP, three molecules of reduced NAD (NADH) and one of reduced FAD (FADH) are also formed in the process. These NADH and FADH are loaded with high energy electrons and act as electron donors to the electron transport chain with consequent release of energy. Fats and some amino acids could also get converted into acetyl Co-A by different mechanisms and can consequently enter the Krebs cycle. Thus the Krebs cycle does not 'burn' only carbohydrates but also uses fats and some amino acids derived from the breakdown of proteins in the form of acetyl Co-A.

Electron transport. Fig. 3 shows the crucial stage of the respiratory sequence in which maximum energy is liberated. The coenzymes NAD and FAD, that have accepted electrons during conversion of glucose to pyruvic acid, pyruvic acid to acetyl coenzyme A, and during various intermediate steps of Krebs cycle now feed them to electron transport chain for being ultimately transferred to oxygen. The electrons with NADH and FADH have a relatively high energy level. These electrons then flow

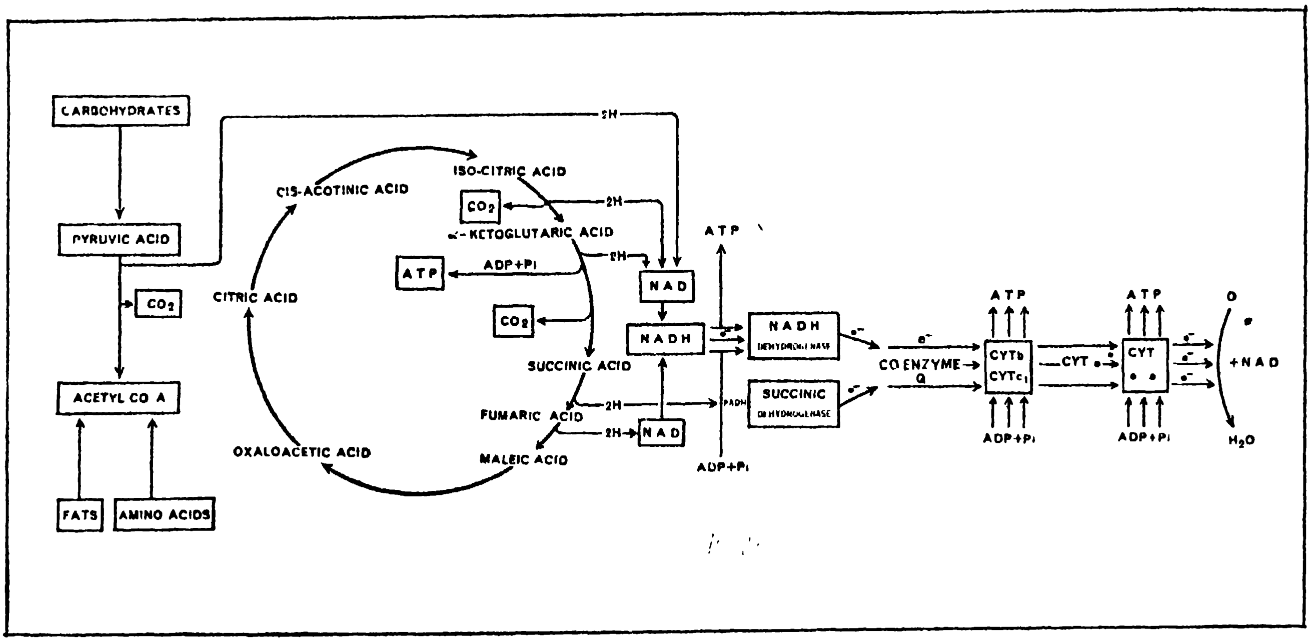

Fig. 4. Chart showing steps during complete oxidation of pyruvate in mitochondria

from higher energy level to lower level (to oxygen) liberating energy. The electron transport chain is a device like the 'conveyor belt' system for the electron pairs of reduced coenzymes NADH and FADH. Nature has engineered this 'conveyor belt' comprising flavoproteins, non-heme iron proteins, and cytochromes placed in a sequence of graded redox potentials. Thus electrons from NADH and FADH smoothly travel 'down hill' through a series of these enzymes, whose assembly line behaves just like a metallic conductor for electric current, and are finally accepted by oxygen. The oxygen combines with spent electrons from the electron transport chain, and with the hydrogen ions released from NADH and FADH in course of oxidation forms water. The components of electron transport chain are arranged in the sequence: NADH dehydrogenase, succinic dehydrogenase, coenzyme Q, cytochromes b and c_1, cytochrome c and cytochrome aa_3. Most of these enzymes have a central core of iron ions which facilitate their continuous oxidation and reduction alternately. All these complexes have been studied in detail and quite often a number of electron acceptor sites in each component have been revealed. Also, specific inhibitors to stop electron transfer at each step in the chain have been found out which have helped the study of different segments of the chain. These inhibitors (e.g., cyanide) are usually potent poisons since they stop oxygen uptake which results in death. One significant member of the electron transport chain is coenzyme Q, a quinone, which is the only non-protein member of the chain.

Oxidative phosphorylation. As pointed out earlier, the flow of electrons from high energy NADH to low energy oxygen would result in release of energy. Just as a paddle which is driven by energy from down hill flow of water could be coupled with any machinery to generate mechanical or electrical energy, the flow of electron through a series of carrier in electron transport chain is coupled with certain enzymes called 'coupling factors' at various steps in the chain. These 'coupling factors' efficiently package the energy released during electron flow by synthesizing ATP molecules from ADP and inorganic phosphate. The process of formation of ATP during electron transport is called oxidative phosphorylation and is not as yet fully understood. However, it is well established that each time a pair of electrons flows through electron transport chain, 3 molecules of ATP are formed. Similarly, two molecules of ATP are formed for each pair of electrons passed from FADH to O_2.

Efficiency of the system

Thus we see that solar energy is captured in green plant cells by chloroplasts to form energy-rich carbohydrates which serve as fuel for the biological power house, i.e., mitochondrion, which subsequently converts the chemical energy of 'foodstuffs' into readily available energy for cellular work in the form of ATP.

Let us work out the efficiency of this system. By anaerobic breakdown of C_6 glucose to C_3 pyruvic acid (two molecules) there is a net gain of energy equivalent to 2 molecules of ATP. Also, two molecules of NAD are reduced during the process each carrying one pair of electrons. When these two pairs of electrons roll down from NADH to oxygen through electron transport chain, energy in the form of 6 molecules of ATP is gained. Thus net gain of energy through the first phase of glucose breakdown is formation of eight ATP molecules synthesized from ADP and inorganic phosphate. The oxidation of each of the two pyruvate molecules to acetyl Co-A produces an additional NADH molecule (one pair of electron) which gives 3 molecules of ATP each. Thus conversion of 2 molecules of pyruvate to acetyl Co-A arising from one glucose unit gives 6 more molecules of ATP. In each round of the Krebs cycle there is a net gain of one molecule of ATP, 3 molecules of reduced NAD (NADH) equivalent to 9 ATP and one molecule of FADH equivalent to 2 ATP, making an overall gain of 12 molecules of ATP per acetyl Co-A residue or 24 ATP per glucose unit. On summing up all the stages together we see that complete oxidation of each glucose molecule results in formation of 38 molecules of ATP from ADP and inorganic phosphate. Only 2 of these 38 molecules are formed during glycolysis outside the mitochondria and rest of 36 are formed by oxidative phosphorylation within mitochondria.

Energy liberated by the breakdown of 38 ATP molecules to ADP is roughly equal to 60 per cent of the total energy available on burning one glucose molecule. Hence the efficiency of energy transfer mechanism could be taken as 60 per cent. It may be pointed out that even in a highly evolved gasoline engine only 25 per cent of the total energy, liberated during the combustion of fuel, is converted into useful work. In other words, the efficiency of 'mitochondrial engine' is more than twice that of the most sophisticated man-made heat engine.

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POLYMERS *(Continued from page 167)*

for its high tensile strength. Most synthetic rubbers, however, lack this property and need fillers, such as fine particles of carbon black, as reinforcement. Among the other additives are: *stabilizer*—which helps to prevent the polymer chain from degrading; *colorant*—a dye as a solution or pigment which imparts a distinctive and desired color to the final product; *flame retardant*—which imparts flame resistance to the final polymeric product; and *antioxidant*—which reduces the tendency for oxidation to occur.

To sum up, we have learned that several factors influence the properties of the final polymeric product. Manipulating two or more of these factors can help in tailor-making a polymer with desired properties.

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Liquid—Liquid Extraction and Its Application in Metallurgy

S. S. DARA

The liquid-liquid extraction process encompasses a number of systems for metallurgical separation of materials from mine waste and dump leach liquors, purification steps in base metal extraction operations and treatment of anode slimes and flue dusts

THE liquid-liquid extraction process is receiving widespread attention because of its wide scope, rapidity, simplicity and versatility. Further, it is applicable to both trace and micro levels of concentration. The origin of this technique dates back to the middle of the 19th century when uranyl nitrate was extracted into ether, cobalt thiocyanate into a mixture of amyl acetate and ether, and iron from concentrated hydrochloric acid into ether.

However, the widespread interest in solvent extraction for recovery of metals stemmed largely from the development of technology for extraction and purification of metals for nuclear applications around 1945-1955. Although initially the technique had been used only to extract important metals, the recovery of more common base metals by liquid-liquid extraction is receiving increased attention.

Basic principles

The liquid-liquid extraction process involves contact of two immiscible liquids (usually one is aqueous and the other organic) and transfer of one or more components from one phase to the other. Thus, separation of components in solution depends on difference in their relative solubility in the two phases.

When an aqueous solution containing the desired metal M is contacted with a suitable organic solvent usually called an extractant, the metal gets distributed between the two phases and at equilibrium,

$$D = \frac{M_O}{M_A}$$

where M_O and M_A are the total concentrations of the metal M, in all chemical forms in the organic and aqueous phases respectively, and D is the distribution coefficient. Only when D is very large it is possible to remove a solute quantitatively in a singleextraction. The completeness of an extraction depends not only on the value of the distribution ratio but also on the volumes of the phases and on the number of extractions performed.

The best method of extraction with a given volume of extractant is to employ several fractions of it rather than to utilize the whole quantity in a single extraction. This

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will be obvious by the following expression:

$$X_n = X_o \left[\frac{DV}{DV+v} \right]^n$$

where X_n is the weight of the solute remaining in aqueous layer after V ml. of the aqueous layer containing X_o gm of a solute is extracted in n times with v ml. portions of the given extractant.

Further, if the aqueous solution containing the desired metal M also contains other metallic impurities (say, M_1, M_2, etc.), the degree of separation achieved in one equilibrium stage is indicated by the ratio of the distribution coefficients D_M/D_{M_1}, D_M/D_{M_2}, etc., which are usually referred to as their separation factors. For good separations these factors should be much larger or much smaller than unity.

Stripping. After the desired metal is extracted in a suitable solvent, the metal value is recovered from the loaded organic phase by a process called stripping. Stripping involves contact of the loaded organic phase with a suitable aqueous solution containing acids or some other reagents whereby the metal is completely back-extracted into the aqueous phase. When more than one metal are co-extracted, they may be separated by selective stripping as in the case of Sc-Th, Mo-Zr and Nb-Ta separation processes.

Choice of solvent. The solvent chosen for extraction should satisfy the following considerations:

(1) A high distribution ratio for the solute and low distribution ratio for the impurities.

(2) Low solubility in the aqueous phase and chemical stability.

(3) Sufficiently low viscosity and sufficient density difference to avoid emulsion formation.

(4) Low toxicity and low inflammability for safety.

(5) Reasonable cost and ready availability.

(6) Ease of recovery of solute for subsequent processing.

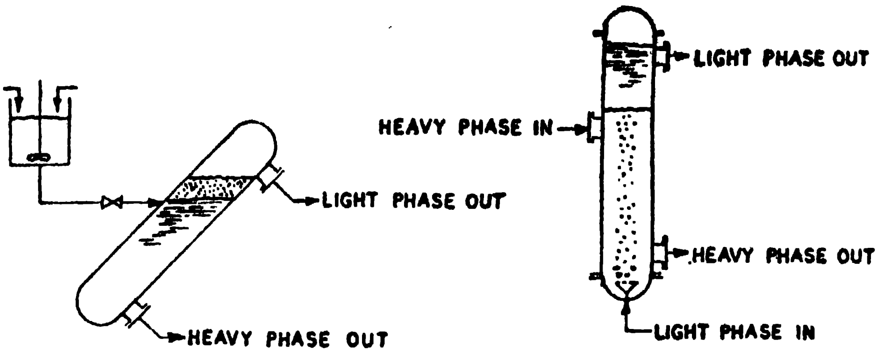

Fig. 1. **Apparatus for industrial separations: Batch operation (left); Continuous-contact operation (right)**

Sometimes, it is possible to achieve many of these characteristics by employing mixed solvent systems or using a diluent to the solvent.

It is generally known that hydrated inorganic salts tend to be more soluble in water than in organic solvents, whereas organic substances tend to be more soluble in organic solvents than in water unless they incorporate a sufficient number of hydroxyl, sulphonic or other hydrophilic groups. In solvent extraction of metals, the water solubility of inorganic cations will have to be masked by interaction with appropriate (mostly organic) reagents, which will in effect remove some or all of the water molecules associated with the metal ion to which the water solubility is due.

Uncharged metal complexes are usually soluble in organic solvents. They may be formed by the combination of metal ions either by co-ordination (generally giving rise to chelation complexes) or by ion-association. In chelation complexes (sometimes referred to as inner complexes when uncharged) the central metal ion coordinates with a polyfunctional organic base to form a stable ring compound, e.g., cupric acetylacetonate or ferric cupferrate. The chelating agents such as acetylacetone, cupferron, dithizone, 8-quinolinol, etc., form uncharged, essentially covalent compounds with metal ions which are readily soluble in organic solvents. Chelating agents such as dipyridyl or EDTA which form charged chelates are useful as metal masking agents.

In ion-association complexes, the inorganic ion associates with oppositely charged ions to form a neutral extractable species. Two types of ion-association complexes may be recognised. The first includes those ion-pairs formed from a reagent having a large organic ion, such as tetraphenylarsonium-ion or tribenzylammonium ion which combine with a suitable metal-containing ion (e.g., the per-rhenate ion, ReO_4^-) to give large ion aggregates or clusters. In the second type of ion-pair, solvent molecules are directly involved in its formation. Thus in the extraction of uranyl nitrate with isobutyl alcohol, the extractable complex is probably $[UO_2(Bu\ OH)_6].(NO_3)_2$, in which the coordinated solvent molecules contribute both to the size of the cation and the resemblance of the complex to the solvent. In most of the solvents (ethers, ketones, and alcohols) which participate directly in the formation of ion-association complexes, oxygen atoms form coordinate linkages with the metal atoms. In the extraction of ion-association complexes, the extractable metal may be contained either

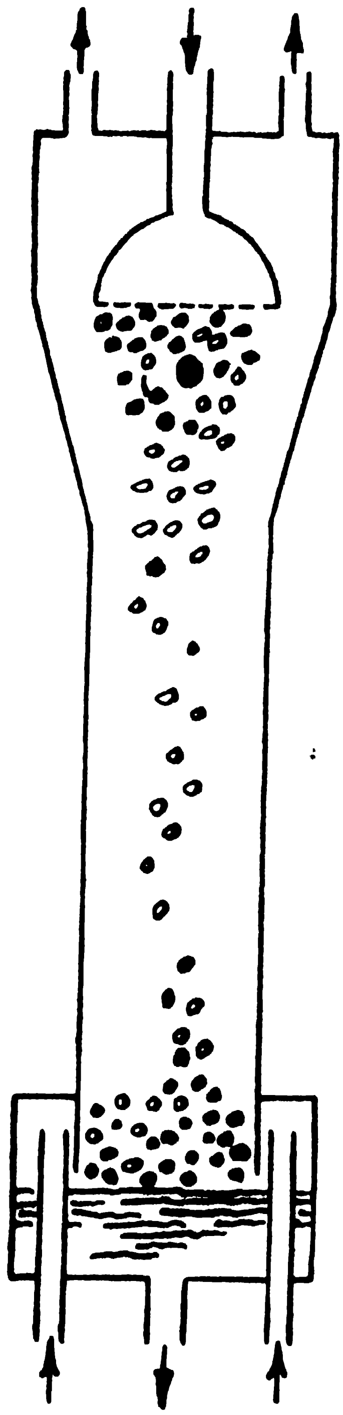

Fig. 2. Spray column

in the cationic member of the ion-pair (as in the case of extraction of metals by alkyl phosphoric acids, carboxylic acids, cationic chelates such as phenanthrolines and polypyridyls, trialkyl phosphoric oxides, etc.) or in the anionic member of the ion-pair (as in the cases of extractions of halides, e.g., $(GaCl_4)^-$, thiocyanates,e.g., $[Co(CNS)_4]^{2-}$, oxanions $(MnO_4)^-$,anionic chelates, e.g., [Co (Nitroso R salt)$_3$]$^{3-}$, etc.,) by the "onium" compounds such as

(a) oxonium, e.g., $R\,OH_2^+$,R_2OH^+ $R\,CoH^+$,
(b) ammonium, e.g., RNH_3^+,R_4N^+,
(c) arsonium, R_4As^+,
(d) phosphonium, R_4P^+,
(e) stibonium, R_4Sb^+,
(f) sulphonium R_3S^+.

Types of extraction systems

It is often convenient to classify extraction systems according to the extractant or solvent types used.

Inert solvents. They extract only non-polar species, such as iodine or metal chelates. They are also used as diluents (for the other solvents,) e.g., carbon tetrachloride, chloroform, cyclohexane, etc.

Basic extractants. They extract mainly by solvating either hydrogen ions or metal ions. Examples: (a) extraction of acids or anionic metal complexes as in the extraction of plutonium (IV) from hydrochloric acid by tri-*n*-octylamine in xylene, and (b) extraction of uranyl nitrate with tri-*n*-butyl phosphate.

Acidic extractants. They extract usually by the cation exchange reaction, exchanging hydrogen ions for the extracted cations, e.g., dialkyl phosphoric acids and carboxylic acids.

Chelating extractants. They form reasonably strong co-ordinate bonds with the metal ions, e.g., 8-hydroxy quinoline, thenoyl trifluoro-acetone, etc.

Ionic extractants. They occur either as dissociated ions or as undissociated electrolytes, depending on the dielectric constant of the diluent, and the active extractant may either be the cation (e.g. tetraphenyl arsonium) or the anion (e.g., tetraphenyl boride). However, some extractants belong to more than one class according to the environment in which they are used.

Factors influencing extraction

Salting-out agents. Addition of high concentrations of inorganic salts to the aqueous phase greatly enhances the extraction of metals. This is called 'salting out effect' and is explained to be due to the pronounced effect of the added salt on the activity of the distributing species by the common-ion effect, as well as the strong ability of these ions to bind water around them, thereby depleting the aqueous phase of water molecules for use as a solvent.

pH. Extraction processes are usually pH-dependent. Also, when two metals are of interest, they may be extracted at different pH values as in the case of U and V extractions. Sometimes, efficient stripping of the loaded organic phase can be achieved by simply contacting with another aqueous phase at a different pH.

Oxidation state. Modification of the oxidation state of either the metal of interest or the impurity sometimes increases the selectivity of an extraction. Thus, the extraction of iron from chloride solutions can be prevented by reducing to Fe (II), which does not extract. Similarly, Pu (IV) is more readily extracted than Pu (III) by TBP.

Conversely, variation of the valence states of certain elements in the organic extract is sometimes useful as a method of stripping.

Masking or sequestering agents. These agents are metal-complexing agents which serve to prevent particular metals from taking part in their "usual" reactions and thus remove their interference without the necessity of an actual separation. In solvent extraction, masking agents are used to prevent certain metals from forming extractable complexes and thus greatly increase the selectivity of the extraction methods. For example, Al can be extracted in presence of iron with 8-quinolinol by masking iron with an alkali cyanide to form stable ferrocyanide

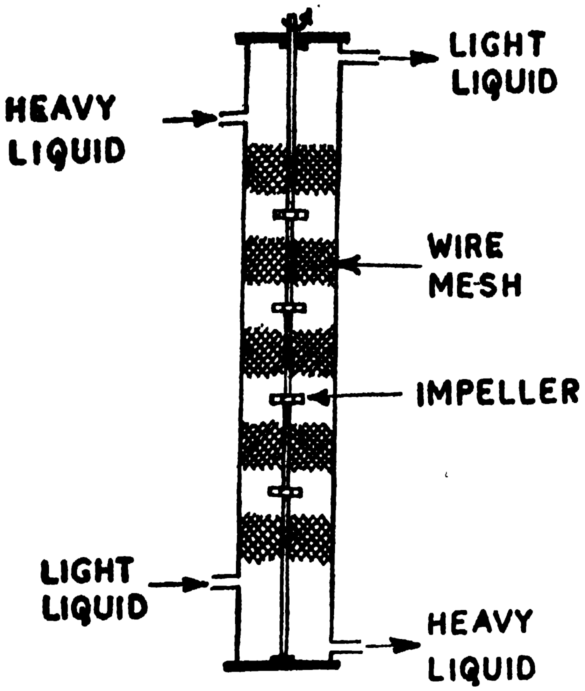

Fig. 3. The Scheibel column (schematic)

ion. The masking agents generally employed include cyanide, tartrate, citrate, fluoride and EDTA.

Synergistic agents. Additives to the organic phase which enhance extraction are known as synergistic agents. They apparently form complexes with particular metallic species which are then taken up by the extractant, even though the extractant itself may not form suitable complexes directly with the desired metallic species. Neutral organophosphorus compounds added to acidic organophosphorus compound (e.g., TBP added to D2 EHPA in kerosene or TOPO added to TBP) exert synergistic effects. Extraction of some cations by TBP can be increased 10^3-10^4 times by the addition of 1% thenoyl trifluoroacetone to it.

Modifiers. Additives to the organic phase to increase the solubility of the extractant in diluent are called 'modifiers'. High molecular weight alcohols, e.g., capryl alcohol, are often employed for this purpose.

Nature of the anion. The anion of the metal salt also affects extraction. For example, ferric chloride is better extracted than ferric sulphate by ether; nitrates are most easily extracted by TBP, chlorides by amines, etc.

Methods of extraction

Apparatus for industrial separations may be either batch or continuous contact type (Fig. 1). Batch extraction, the simplest and most widely used method, is employed where a large distribution ratio for the desired separation is readily obtainable. In the batch operation, the two phases are brought into contact, agitated and allowed to settle. A small number of equilibration steps are sufficient to remove the desired component completely. When the distribution ratio is low and the separation factor is high, continuous methods of extraction are useful. The procedure makes use of a continuous flow of immiscible solvent phase through the solution to be extracted. If the solvent is volatile, it can be stripped and recycled by distillation and condensation and is dispersed in the aqueous phase automatically by a suitable device. As the extractant passes through the solution, baffles and stirrers may be used to bring the two phases into closer, more effective and prolonged contact.

There are many types of batch as well as continuous counter-current extractors in commercial use. The feed preparation is generally carried out in stainless steel or concrete tanks provided with heating and cooling coils, a suitable mixing arrangement and a manhole. Vertical or horizontal extraction vessels, respectively known as columns and mixer-settlers, are generally used. In continuous operation using mixer settler units, the liquids are continuously pumped through the agitated vessel (the mixer) in parallel flow, the resulting dispersion is continuously settled or decanted in a separate vessel (the settler). Each mixer settler constitutes one stage of extraction and multistage effects may be had by arranging any desired number of mixer settlers according to any desired flow-sheet.

Occasionally, rotary columns, pulsed counter-current columns, pumper decanters, centrifugal extractors or hydrocyclones are also employed. The principal object of any type of extractor is to achieve close contact between the phases so as to ensure rapid and efficient transfer of solute to the desired phase. To achieve this objective, a number of columns are in commercial use some of which are shown in Figs. 2 to 5.

Metallurgical applications

Analytical liquid-liquid extraction procedures have been developed for separating practically all the metals recovered by hydrometallurgical processing. Although many of these analytical procedures could be extrapolated to full-scale commercial

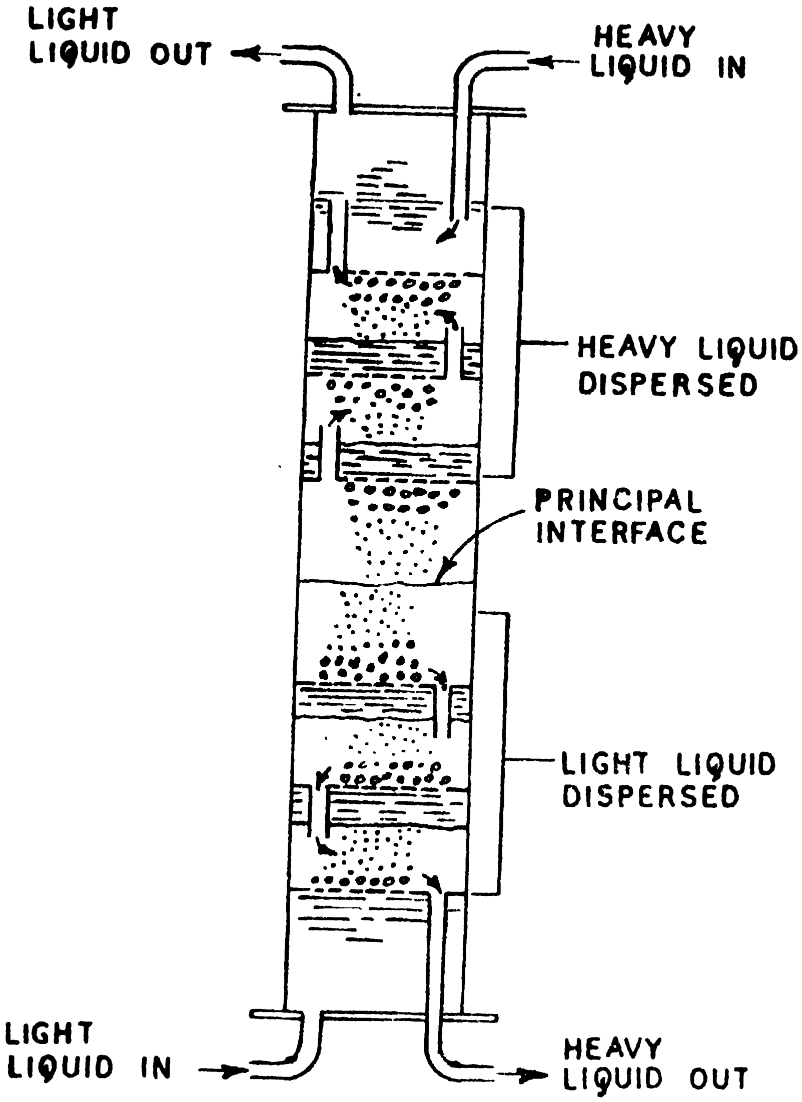

Fig. 4. Perforated plate column

hydrometallurgical processes from the technical point of view, the economic factors preclude such a development in most cases.

Liquid-liquid extraction can be applied in metallurgy for the following operations: (1) extraction of metal values from leach liquors obtained from low-grade or complex ores, (2) separation of metals which are either chemically similar or occur together in ore deposits and are difficult to separate by the conventional pyro- and hydro-metallurgical techniques, (3) concentration of metal values by extracting them from a very large volume of aqueous solution, and (4) purification to obtain a purer starting material for further metallurgical processing.

The first commercial liquid-liquid extraction process was developed by the U.S. Atomic Energy Commission in 1942 for the recovery and purification of uranium by extracting uranium nitrate in ether. Within a decade thereafter, commercial liquid extraction processes were developed for the separation of niobium and tantalum, for the recovery of thorium and vanadium from uranium processing circuits, and for processing tungsten ores. Since then, a number of separations of industrial importance have come into vogue.

The United States Atomic Energy Commission developed solvent extraction processes in the immediate post-war period for re-processing of spent nuclear fuels and the extraction and purification of uranium and thorium. Reagents used in the recovery of uranium include alkyl phosphoric acids such as tributyl phosphate (TBP) and bis (2-ethyl hexyl) phosphoric acid as well as various secondary and tertiary amines. Similarly, uranium and thorium have been separated and recovered from rare earth metals in monazite leach liquors by employing TBP in xylene. Also, purification and recovery of uranium and plutonium from the radioactive fission products such as ^{90}Sr, ^{147}Pm, ^{144}Ce and ^{137}Cs have also been achieved by employing extractants as TBP.

Increasing utilization of pure rare earths in phosphors for picture tubes and colour television sets, and also their high unit value make liquid-liquid extraction a potentially useful tool for the extraction and separation of these metals. The solvents used include acetyl acetone, benzoyl acetone, dibenzoyl methane, phenyl carboxylic acid, dodecyl phosphoric acid, TBP and D2 EHPA.

Copper can be preferentially extracted by Lix-63 and Lix-64. In fact, such a process is being commercially used in Arizona (U.S.A.) and Zambia.

Solvent extraction methods have been adopted recently for the extraction of beryllium from low-grade beryllium ores. The solvent systems investigated include TBP, DDPA, D2 EHPA, MIBK and methyl *p*-tert-octyl-phenyl phosphate. The Brush Beryllium Company exploited the solvent extraction technique commercially by using a kerosene solution of an organo-phosphate ester from sulphate solution.

Boric acid can be obtained by solvent extraction technique from

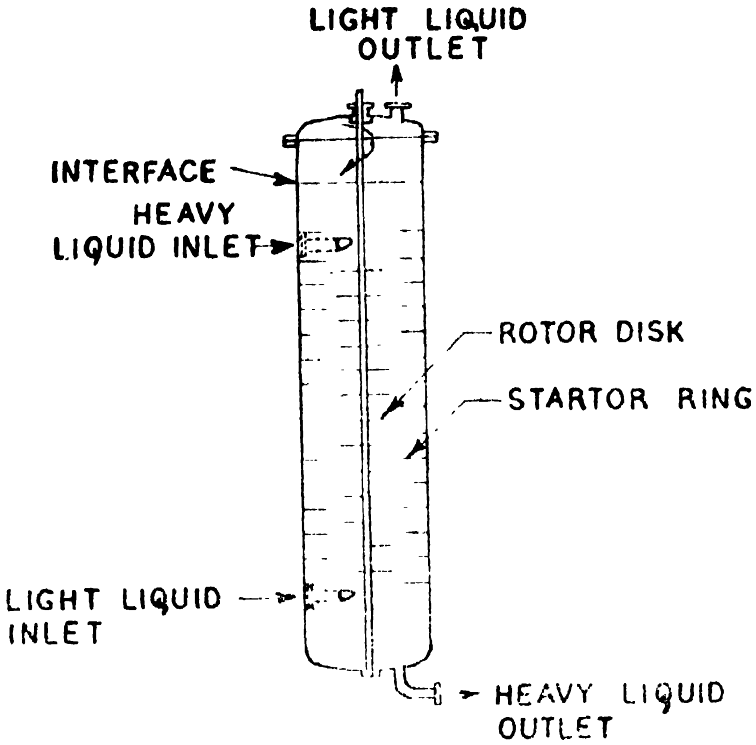

Fig. 5 Rotating disc column

certain locally occurring low-grade brines containing about 1% $Na_2B_4O_7$ using aliphatic or aromatic polyols dissolved in kerosene as the extractant.

Tantalum can be separated from niobium by preferentially extracting the former element by methyl isobutyl ketone (MIBK) from acid aqueous mixtures, (e.g., $HCl—HF$). This commercial process was developed as early as in 1958. Other solvents such as methyl cyclohexanone, hexone and TBP may also be employed with advantage.

Zirconium is extracted preferentially to hafnium by TBP or by TIOA from nitric acid solutions. Similarly, hafnium can be preferentially extracted by MIBK from an $HCl\text{-}NH_4CNS$ solution commercially. These methods have been very useful for preparing reactor-grade zirconium-free hafnium.

A number of other separations of metallurgical importance have been recently investigated

Conclusion

Analytical techniques based on liquid-liquid extraction have been developed for most metals. However, development of commercial processes has been limited only to metals of relatively high unit value, e.g., U, V, W, Zr, Hf, etc. Recently, processes using naphthenic acid, bromo-lauric acid and other reagents have been developed for hydrometallurgical circuits involving the recovery of Cu, Ni and Co. Other applications such as for purification steps in base metal extraction operations, treatment of anode slimes and flue dusts, and removal of elements such as As and Sb from electrolytes are also being investigated.

Areas for further development include purification of hydrometallurgical processing streams, mine wastes and dump leach liquors, recovery of valuable and toxic metals from waste streams, extraction of various metals from the concentrated brines from desalination process, etc. The future development of liquid-liquid extraction lie not only in the wider utilization of the processes currently available but also in developing new, selective and economic processes suitable for processing complex and marginal ore reserves which is of vital importance for developing countries like India.

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ORAL CONTRACEPTIVES

CHANDRA B. SHARMA
SURINDER CHHINA

Contraceptive pills containing hormones estrogen and progesterone act by inhibiting ovulation and altering the uterine environment so as to prevent fertilization of the ovum

POPULATION growth, particularly in the Asian countries, has reached a stage which demands special attention before it is too late. In India, fortunately, the family planning programme is being implemented with all seriousness and even the people living in rural areas have become aware of the need for a small family. Different methods, ranging from oral contraceptives to loops and surgical operations, are being practised. Oral contraceptives, commonly known as "pills", appear to be the best device and a rough estimate shows that 14,000,000 women the world over use them.

The subject of oral contraceptives has been a controversial issue in this country and elsewhere for various reasons. It is not intended here to take a pro or con view on the use of pills but to give an idea of the types of chemicals being used and their effects on the human body.

The ovarian cycle

The ovarian cycle of a woman comprises three major subcycles. They represent the initial development of the ovaries, attainment of maturity and senescence or old age. The second subcycle is that of fertility which lasts thirty to forty years. It is referred to as the ovarian cycle. The ovarian cycle goes through secondary rhythmic cycles which are defined as the intervals between periods of uterine bleeding and stretch approximately over twenty-eight days. Precisely, this is the menstrual cycle.

Ovaries are situated on each side of the uterus and contain ovarian follicles—the cavities which hold eggs or ova (Fig. 1). Each month or every 28 days, one of the follicles bursts and releases the ovum. At this point during the cycle the female is most fertile. If the egg is not fertilized, the uterine lining breaks down and sloughs off as menstrual bleeding.

The control or regulation of the menstrual cycle is exercised by four different chemical agents. These are: follicle stimulating hormone (FSH), luteinizing hormone (LH),

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estradiol, and progesterone. Secretion of FSH stimulates ovarian follicles to rupture and release egg. Formation of the corpus luteum is brought about by LH. It has been found that LH acts synergistically with FSH. Estradiol is involved with the growth of the uterine lining and the progesterone with the preparation of the lining for implantation and nutritive support of the fertilized egg, and prevention of the development of more follicles and eggs. Estrogen and progesterone collectively inhibit secretion of FSH and LH. A schematic representation of the overall events occurring in the ovarian cycle of the female is shown in Fig. 2.

When fertilization has taken place, progesterone continues to be secreted which prevents FSH and LH from developing more eggs. It also prevents the uterine lining from breaking down and ejecting the fertilized egg during the early part of pregnancy. This occurs till the placenta starts secreting chorionic gonadotropin to maintain pregnancy upto the delivery.

Basically, an oral contraceptive acts to form a condition of pseudo-pregnancy in the ovaries. During pregnancy there is no formation of a new ovum. Therefore, if there is no ovum to fertilize there can be no pregnancy. The pill made up of synthetic progesterone and estrogen was found to have a threefold action. First it inhibits ovulation. This is done through pituitary depression which suppresses the production of FSH and LH. Secondly, it makes endometrium (the mucus membrane of the uterine cavity) unsuitable for implantation of ovum. This is done with endocrine substances which alter endometrial surface so that it becomes unsuitable for holding the ovum. Thirdly, it makes the cervical mucus impenetrable to the sperm, that is, it changes the mucus from a normal, thin, watery type to a thick, viscous type

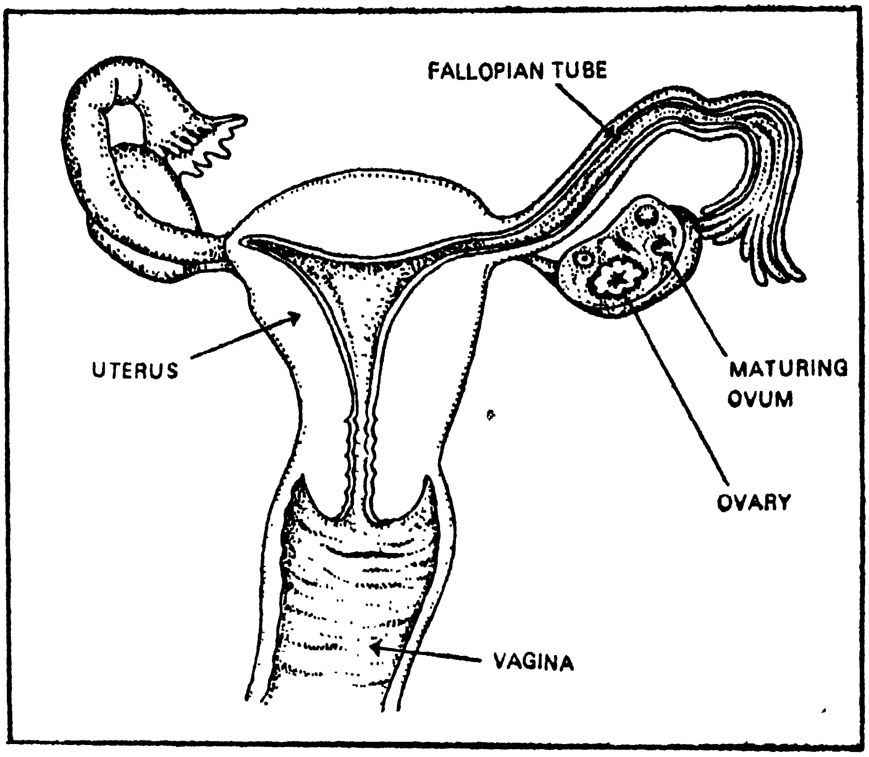

Fig. 1 The female reproductive organs

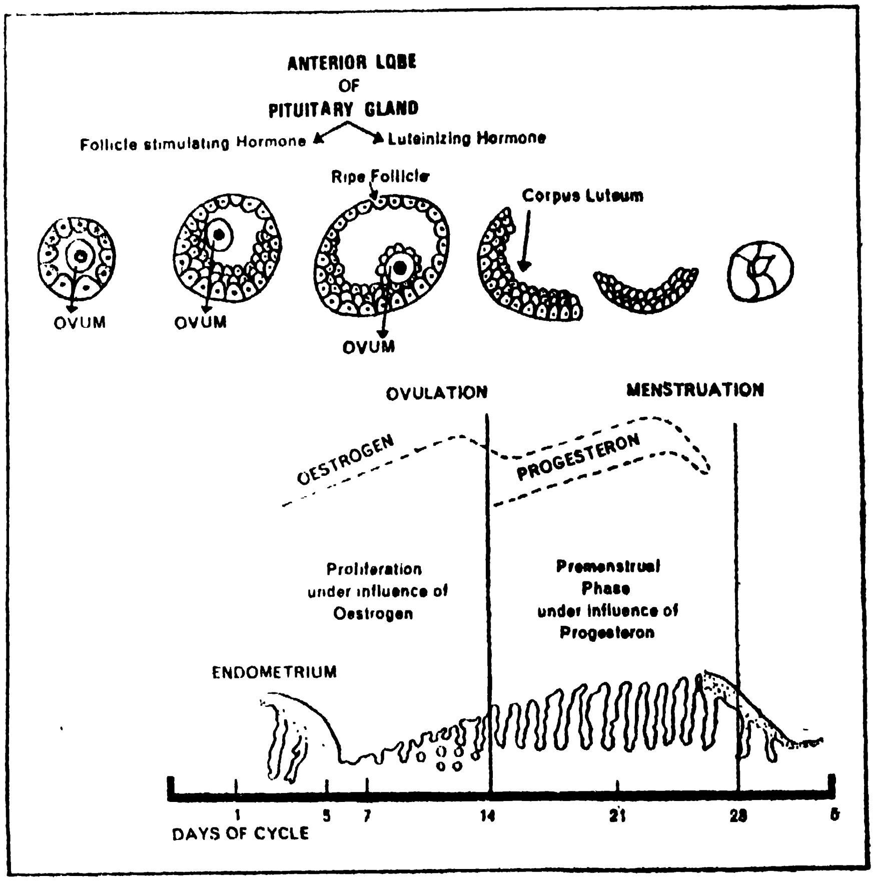
ANTERIOR LOBE OF PITUITARY GLAND
Follicle stimulating Hormone
Luteinizing Hormone
Ripe Follicle
Corpus Luteum
OVUM
OVUM
OVUM
OVULATION
MENSTRUATION
OESTROGEN
PROGESTERON
Proliferation under influence of Oestrogen
Premenstrual Phase under influence of Progesteron
ENDOMETRIUM
1
5
7
14
21
28
5
DAYS OF CYCLE

Fig. 2. The ovarian cycle

Table 1. Oral contraceptives

Product	Manufacturer	*FDA Clearance	Composition of the pill			
			Progestin		Estrogen	
Enovid	G.D. Searle	June 1960	Norethynodrel	9.85 mg	Mestranol	0.15 mg
Enovid	G.D. Searle	March 1961	Norethynodrel	5 mg	Mestranol	0.075 mg
Enovid-E	G.D. Searle	Feb. 1964	Norethynodrel	2.5 mg	Mestranol	0.1 mg
Ortho-Novum	Ortho-Pharmaceutical	May 1962	Norethindrone	10 mg	Mestranol	0.06 mg
Ortho-Novum	Ortho-Pharmaceutical	Oct. 1963	Norethindrone	2mg	Mestranol	0.1 mg
Norinyl	Syntex	March 1964	Norethindrone	2 mg	Mestranol	0.1 mg
Norlestrin	Park-Davis	March 1964	Norethindrone-acetate	2.5 mg	Ethynyl-estradiol	0.05 mg
Provest	Upjohn	August 1964	Medroxyprogesterone acetate	10 mg	Ethynyl-estradiol	0.05 mg
Ovulen	G.D. Searle	March 1966	Ethynodiol-diacetate	1 mg	Mestranol	0.1 mg
Oracon	Mead Johnson	April 1965	Dimethisterone	25 mg	Ethynyl-estradiol	0.1 mg
C-Quens	Eli Lilly	April 1965	Chlormadinone-acetate	2.0 mg	Mestranol	0.08 mg
Ortho-Novum SQ	Ortho-Pharmaceutical	Dec. 1966	Norethindrone	2 mg	Mestranol	0.08 mg
Ortho-Novum-1	Ortho-Pharmaceutical	Feb. 1967	Norethindrone	1.0 mg	Mestranol	0.05 mg
Norinyl-1	Syntex	Feb. 1967	Norethindrone	1.0 mg	Mestranol	0.05 mg

*Federal Drug Administration (U.S.A.)

difficult for the sperm to penetrate.

Seven synthetic progesterones and two synthetic estrogens are currently being used in oral contraceptives. The reason for using synthetic steroids in oral contraceptives in preference to natural steroids is that the action of the latter is weak compared to the former. Table 1 shows the quantity of steroids in different pills.

Side effects of pills

From experimental trials of oral contraceptives there has come a large list of adverse effects of the drugs used. Some of the side effects are irregular bleeding, weight gain, gastrointestinal symptoms, acne and symptoms of pregnancy, i.e., breastfullness and discomfort, headache, dizziness, edema and chloasma (yellow patches on the face and neck of pregnant women). In most cases these symptoms diminish with continued usage. Estrogen has been found to be responsible for gastrointestinal side effects but only in one reference. Other side effects noted include menstrual cycle becoming more regular and lessening of menstrual pain.

Norethindrone, an oral contraceptive commonly used today, was the first to be studied in 10 mg/day dosages. However, it was found that by lowering the dosage to 2 mg/day the protection against pregnancy was equivalent and the normal side effects, i.e., nausea, etc., were noticeably lowered.

During studies of pills no instances of cancer, significant changes in blood counts, or indications of precancerous changes have been observed. Though oral contraceptives have been associated with jaundice, such cases are rare and usually a history of idiopathic jaundice of pregnancy is involved.

Effects of oral contraceptives do not persist after their use is discontinued. Fertility is recovered. There is some indication that their use may decrease or increase the sex urge; however, this tends to vary from person to person. 'Male pill' has been reported recently in the scientific literature but it would take time before one can buy it from the drugstore.

Further reading

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SCIENCE SPECTRUM

Tenth planet in the solar system

HOW many planets are there in our solar system? If you put this question to an astronomer he is likely to answer: There are nine known planets and, possibly, a tenth planet. This possiblity has become a probability with the recent announcement of the 'discovery' of the tenth planet by Dr. Joseph Brady of the University of California (U.S.A.).

This discovery is not a discovery in the sense that the new planet has been sighted or photographed; it is just a mathematical calculation showing that the motions of the known planets, especially the path of Uranus, can be explained and accounted for only by the presence of planet X (X here standing for both the Roman numeral ten and the mathematical symbol for the unknown).

The story of the discovery of planets goes back to the 18th century when the British astronomer Sir William Herschel accidentally discovered Uranus, the seventh planet in our solar system. Till then everybody assumed there were only six planets—Mercury, Venus, Earth, Mars, Jupiter and Saturn—going round the sun. This happy illusion was shattered by Sir William's discovery of Uranus orbiting at an average distance of about 178 million miles from sun. Once this new planet was discovered, astronomers started wondering about the still undiscovered planets and focussed their telescopes in the search for new planets, but without success.

By the beginning of the 19th century the study of celestial bodies found a theoretical basis in the understanding of Newton's laws of mechanics, and the celestial mechanics formulated bythe French mathematician Pierre Simon Laplace. With the help of these mathematical tools, astronomers could chart the paths and courses of known celestial bodies without actually observing them in the telescopes. But how can this help in the discovery of new planets? First chart theoretically the path of a known celestial body and then follow its path by telescopic observation. If there is any discrepancy it is to be due to the influence of an unknown celestial body in the path observed.

The most important of such influences is perturbation, the result of mutual gravitational effects of planets as they approach each other. These perturbations indicate when a planet has been overtaken in its orbit by another planet.

For example, Saturn takes about 29½ years to complete one orbit, while Uranus takes about 84 years to go around the sun once. Thus Saturn overtakes Uranus at regular intervals. As Saturn approaches Uranus, Uranus slows down a little and Saturn accelerates to a small extent due to the effect of mutual gravitational fields. As they cross each other this trend is reversed. Uranus experiences this perturbation on the inside due to the effects of the gravitational fields of Jupiter and Saturn. If there is perturbation due to the planets which are nearer to the sun than Uranus, why not perturbation due to planets which may be farther away? Thus to look for a new planet observe all the perturbations, slowing downs and accelerations, of Uranus and those that could not be accounted for by the known planets must be due to some unknown planets.

In the 1840's three astronomers—one British, one French and one German—independently set out to solve this problem. The German, F.W. Edemin died in 1840 after he had worked out the problem but before the discovery of the eighth planet. The French astronomer U.T.T. Leverrier and the Englishman J.C. Adams continued their work, without each other's knowledge, and concluded that there must be an eighth planet as big as Saturn and Uranus and orbiting at an average distance of 8110 million km. from the sun. When Adams, an young man in his early twenties, reported his results, the British Astronomer Royal, Sir George Biddel, took a dim view of the young man's calculations and did not start a telescopic search to verify the results. Leverrier after being unable to create sufficient interest in the authorities of the Greenwich Observatory, sent his results and request for a telescopic search to the Urania Observatory in Berlin.

Leverrier however had better luck His request was received in Berlin on September 23, 1846 and on the same day J.G. Gelle, the Director of the Observatory, focussed his telescope and discovered Neptune, the eighth planet at about the same position indicated by Leverrier. Neptune was about the same mass as Uranus and its orbit was slightly inclined to the normal orbits of the planets. However, it was about 450 km. nearer to the sun than predicted by Leverrier and Adams.

Once Neptune was discovered, astronomers started debating the discovery of other unknown planets. The premise for the debate was that Neptune was nearer to the sun than predicted and also it did not account for all the pertubations of Uranus. Also the orbital distance of the new planet broke the well-known Bode-Titus law. This is an empirical law formulated even before the discovery of Uranus, and gives an average distance of each planet from the sun in terms of astronomical units (each AU is about 93 million miles or the average distance of the earth's orbit from the sun). As per this law Neptune's orbit should be at about 38 AU, while actually it is at 30 AU

Taking all these into account, Leverrier himself started the debate about the ninth planet stating that if the Bode-Titus law was not applicable to Neptune there may be another planet which could account for the still unaccounted perturbations of Uranus. Speculations were rife in the late 19th century and astronomers of different observatories suggested a new planet at distances varying from 45 to 100 AU.

An American astronomer, Percievel Lowell, worked for 12 years on the problem and on the basis of Leverrier's calculations obtained a probable position for the new planet. He scanned the skies with the help of the new method of photographing the skies for two years during 1905-1907, but without any success. Then, thinking something was amiss with Leverrier's data, he reworked the problem on the basis of new data and published the results in 1915. After Lowell's death in 1916 the enthusiasm petered off and the problem of the ninth planet occupied a secondary position in the astronomical circles.

In 1929, an young astronomer C.W Tombaugh joined the Lowell Observatory in Arizona, where Perceivel Lowell himself worked, and started the search for the ninth planet. By February 1930 he succeeded in photographing Pluto, the ninth planet.

But the Pluto photographed by Tombaugh was different in many respects from the one predicted by Lowell. Lowell anticipated a planet with a mass seven times that of the earth, completing an orbit in about 282 years and with its orbit inclined at about 10° of the arc. But Pluto turned out to have a fraction of the predicted mass, going round an orbit inclined at about 17° and taking only 249 years for its journey round the sun.

So Pluto was not Lowell's planet. Can there be then a tenth planet? Many astronomers believed that there are no more planets in our solar system. However, on the basis of some of the unexplained data a minority continued to think of a tenth planet.

The announced results of Dr. Brady lend support to these optimists' view on the tenth planet. He has analysed the results of the appearances of Halley's comet in the last 1700 years from the recorded data. He found that this comet which comes into our view every 76 years has never kept its schedule. Every time it came four days late or four days before the predicted date. Concluding that this erratic behviour was due to some unknown force influencing its motion, Dr. Brady worked out a mathematical model of a ten-planet solar system and fed the data to the computer. The results showed that there is a planet besides the nine known planets in our solar system. According to Dr. Brady's results it is three times as massive as Saturn, goes once round the sun every 464 year, and travels at an average distance of ten billion km from the sun.

What are the chances of somebody photographing the tenth planet as a proof of its existence? Rather remote. First, it is so far away even in terms of astronomical distances that it will be too faint to be photographed with the available techniques. Secondly, its orbit is inclined at about 60° from the general plane of the planets' orbits and it will not come into the view of the earth soon. But then, who knows, more powerful equipment to photograph the heavens may be developed and the task of observing the tenth planet may be assigned to a satellite in the future. Till some such thing happens we only have Dr. Brady's calculations to show that probably there is a tenth planet around the sun.

P.K. TATINENI

High speed steels

IN any engineering workshop the production rate depends on the type of cutting tools that are employed. High speed cutting tools are generally made of special steels, viz., high speed steels. The cutting durability and the life of the tool depend on the right design and the right type of the material. The latter has no less importance because the high speed cutting tools should have three inherent properties, namely, red hardness, wear resistance and toughness. These can be achieved only by giving proper heat treatment to the cutting tool. Subsequently the tool life is vastly improved. High speed steels are complex alloys of Fe, W, Cr, and V containing usually between 0.5 to 0.8% C. These elements are adjusted in such a way as to obtain the desirable properties in a cutting tool. One such combination is 18W—4Cr—1V and is the most popular one, because at this composition the cutting durable speed of a tool is maximum.

History

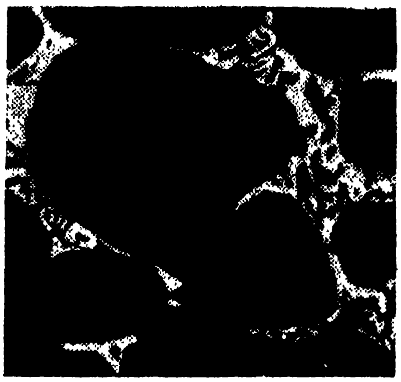
The earliest high speed steels were not invented as such, they just developed from air hardening alloy steels that were available at the end of 19th century. The discovery of Mushet's steel in 1868 was an accidental one. While carrying out experiments on alloy steels, he discovered that one of the bars of the steel he had made seemed to have the property of becoming hard after heating without the usual quenching that had been used earlier for hardening. The analysis of the steel bar showed it to contain tungsten. Mushet then realized how much the property of air hardening might be of advantage in tool steels. He finally prepared a steel under the trade name 'Robert Mushet's Special Steel' of composition 2%C; 2.5% Mn; and 7% W. The red hardness property was recognised after 25 years of its discovery. In 1892, Dr. John W. Longly, an American scientist, suggested that the addition of tungsten alone to steel did not make it self-hardening, it had to be excessively richer in Mn or Cr. In 1904, J.A. Mathews developed the 18W—4Cr—1V steel composition which was considered to be the best high speed steel for many years.

Specific properties

Apart from the fundamental properties like room temperature hardness, abrasion resistance, toughness, hardenability, machinability and thermal conductivity, the high speed steels should possess the following special properties.

Red hardness. The hardness of a steel at elevated temperatures is normally lower than that at room temperature. In many applications, the tools may be required to handle hot material or sufficient heat may develop during the cutting operation which may increase the temperature of the tool to higher levels. In such cases the tool steel should possess high hardness and high wear resistance at elevated temperatures. This ability to retain high hardness at elevated temperatures is known as 'red hardness'. Elements which impart red hardness are W, Mo, Co, V and Cr.

Abrasion resistance. It is the most important property of high speed steels. For good abrasion resistance hard alloy carbides are distributed evenly in a hard matrix. In high speed steels, abrasion resistance can be increased by increasing the vanadium content alongwith carbon content.

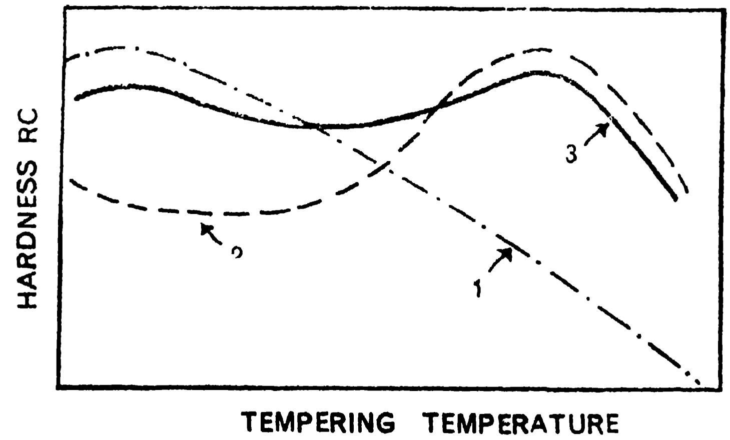


Excessively heated M_{10} steel, grain boundaries are fused (× 1000)

Oxidation resistance. High speed steels possess good oxidation resistance. The main element which imparts oxidation resistance is chromium. In addition to this W, Mo, and V also improve oxidation resistance.

Function of the alloying elements

Of the common elements in high speed steels, carbon imparts the high

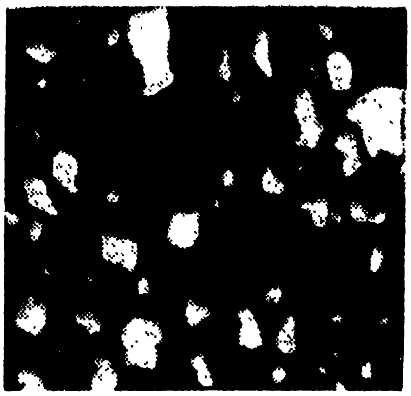


Tempering of high speed steels: 1. Decomposition of austenite, 2. Precipitation hardening caused by special carbides, 3. Tempering curve of high speed steel

attainable hardness and provides carbides which increase its wear resistance. The carbon content varies from 0.7 to 1.6%. Tungsten (12-22%) increases red hardness. It also forms hard complex carbides which are responsible for high wear resistance. Molybdenum can be substituted for tungsten but not completely. Vanadium is added to increase the cutting efficiency. Vanadium carbides contribute to the high wear resistance and fine grain size of these steels. Vanadium is used in small amounts (1-2%). Chromium is added in amounts from 3 to 5%. It increases the hardenability, corrosion resistance, high temperature strength and oxidation resistance. Cobalt (5-12%) is added to get extra red hardness. High speed steels containing cobalt are called 'Super high speed steels'.

Heat treatment

Heat treatment of high speed steels involves two processes, viz., hardening and tempering. In hardening, the high speed steel tools are preheated first at 540° to 650°C and then between 845° and 870°C. The value of preheating is two-fold. It eliminates the severe shock caused by placing the cold tools in hot furnace. The danger of cracking or warping, especially when large sizes are treated, is also minimised. Since the initial formation of austenite (solid solution of γ-iron with carbon, manganese, etc.,) occurs at a temperature around 760 °C, preheating to slightly above this temperature minimises additional stresses that might be set up because of the transformation. Final heating to hardening temperature is done as fast as possible, normally by transferring the steels from a preheating furnace to a salt bath kept at hardening temperature 1200-1290°C depending upon the grade of steel. The soaking time at hardening temperature varies from 2 to 5 minutes, depending upon the section size. Longer soaking times are avoided to minimise decarburization.


Angular carbides formed on over-treated type T_1 steel (×1000)

High speed steels are necessarily austenitized at very high temperatures. If high speed steel tool is austenitized at low temperatures of 850 to 900 °C (like plain carbon steels) and quenched, it develops a low hardness of about 56 to 58 Rockwell hardness. This is because the austenite at this temperature has a relatively lower carbon and alloy content. As the temperature is increased to 1200-1250°C more carbides dissolve making austenite richer in carbon and alloying elements. Underheating results in more of undissolved carbides, as a result carbon and alloy content of austenite gets lower. This leads to a lower hardness on quenching. Sometimes under-hardening is preferred where the tool requires little or no red hardness, but merely good abrasion resistance at room temperature with optimum toughness. Overheating of high speed steel results in the formation of angular carbides or leads to incipient melting along the grain boundaries. Its structure becomes weak. The correctly heated high speed steel tool is quenched from hardening temperature by either (a) a molten salt bath at 600-650 °C and then in air, or (b) an oil bath, till the temperature of the tool comes to about 450 °C and then air cooled to room temperature, or (c) an oil bath to room temperature and requenched to −80 °C.

The quenched steel containing martensite, undissolved carbides and 15 to 30% of highly alloyed austenite is normally tempered to develop maximum secondary hardness. This is accomplished by heating the steel once or more to temperatures in the range 550° to 600 °C. The mechanism of tempering is the depletion of the carbon from martensite matrix to form ε-carbide—an extremely finely divided transition phase which subsequently disappears with the appearance of cementite. Redissolution of cementite and precipitation of complex alloy carbides such as M_2C and VC (M represents tungsten and V vanadium) from martensite give rise to secondary hardening. In the first tempering a larger portion of retained austenite is transformed to martensite. Hence a second heat treatment is given to temper this untempered martensite. In some countries, tripple tempering is also practised.

Nitriding of high speed steel improves the tool life to a large extent. It imparts high case hardness, high wear resistance and low coefficient of friction to the tool. Nitrided surface assists in preventing chip pick-up by lessening the tendency of the chip to weld to the tool.

C. V. SATYANARAYANA

Thin-layer chromatography

THIN-layer chromatography is one of the comparatively recent analytical methods added to the lits that includes adsorption chromatography, partition chromatography, paper chromatography, gas liquid chromatography (GLC), gas solid chromatography (GSC), electrochromatography, ion-exchange chromatography, etc. It has found wide applicability in separation and identification of both organic and inorganic substances. The main advantage of thin-layer chromatography (TLC) lies in the fact that the technique can carry out separation and identification of unknown substances in very small amounts and in a very short time. None of the other methods can match it in this regard. Even paper chromatography which has earned the reputation of carrying out separation in very small amounts has been exceeded by this method. For, TLC can carry out separation or identification in still smaller amounts and in much less time than is taken by paper chromatography.

Like paper chromatography, thin-layer chromatography is a microchromatographic technique in which glass plates are coated with thin layers of adsorbents like alumina, silica gel, kiesel gel, cellulose powder, etc. These adosrbents adhere to the glass plates firmly due to the presence of binding materials added to the adsorbent slurry. The adsorption plates are sometimes called chromato-strips or chromato-plates and are used in a similar manner as paper strips in paper chromatography but they are much easier to handle.

The credit of discovering this new technique goes to two Russian workers, N.A. Izmailov and M.S. Schraiber, who in the year 1938 attempted the separation of plant extracts on alumina-coated glass plates and got a satisfactory separation. This discovery did not attract the attention of other workers till 1949. In that year J.E. Meinhard and N.F. Hall showed some satisfactory separation with the new method. They were also the first to describe an apparatus for coating glass plates with adsorbents. But the technique could not gain popularity because of the difficulties involved in the preparation of suitable adsorbents and applying them in uniform layer on glass plates.

The method which was practically given up was rejuvenated by the untiring efforts of Egon Stahl, a German worker, who not only found a practical equipment for coating glass plates with adsorbents but also demonstrated the usefulness of this technique on a wide range of materials. Since 1958, the use of TLC has been so widespread that it has entered almost every phase of analysis. This is because the technique has been developed to such an extent that good and reproducible results are obtained readily and in a comparatively less time. Since thin-layer chromatography is based fundamentally on adsorption and separation chromatography, the same theoretical principles are involved in it.

TLC has been used in separation and identification of a large variety of organic compounds—alkaloids, terpenes, vitamins, hormones, dyes, drugs, sugars, alcohols, aldehydes, acids, and many others. TLC has also found useful application in the analysis and identification of inorganic compounds.

Technique and materials

Adsorbents and applicators are the two essential items of the TLC technique, although other accessories like glass plates, aligning tray, activating oven, developing chamber, etc., play their individual roles. The efficiency of the former two plays a very important part in the success of the technique.

Applicator. There are various types of applicators for spreading the adsorbent in slurry form over the glass plates which are used in the chromatography. Adjustable applicators are available for spreading adsorbent layers of various thicknesses ranging from 250 μ to 2 mm over glass plates.

Adsorbents. The character of the adsorbent is of the greatest importance in this technique. Silica gel and alumina are mostly used and have proved to be quite suitable. They are used alongwith some binding materials like plaster of Paris to fix the thin and porous layer on the glass plates. Besides, kiesel gel has also been used for making thin layers. Cellulose powders with and without binding materials are also in use. Various types of cellulose powder including ion exchange cellulose powder are in use.

Preparation of thin layers

The adsorbents are mixed thoroughly with requisite quantities of water or mixtures of water and alcohol with the help of a mechanical stirrer for about two minutes to form a homogeneous slurry. Then immediately it is spread over well cleansed glass plates of standard size (20 × 20 cm or 20 × 5 cm) arranged in a row on an aligning tray with the help of the applicator. The applicator is first adjusted for the thickness of the layer, after that the slurry is put inside the applicator and the latter is drawn by hand over the glass plates arranged on the aligning tray. The coated glass plates are then allowed to dry at room temperature for 10 minutes to 2 hours during which the binder present in the adsorbent sets the adsorbent firmly over the glass plates.

After air drying, the coated glass plates are activated by drying in an oven at a suitable temperature depending on the adsorbent. The heating period similarly varies. After activation the plates are stored in a vacuum desiccator until they are used. If the plates are not stored in a desiccator and exposed to air or kept for a long time without being used, the efficiency of the plates decreases.

The samples to be analysed are applied in the same way as in paper chromatography. Usually a small amount, e.g., 4 microlitres of the solution of the substance or mixtures in a micro-pipette is applied to the starting point near one of the edges (narrow edge) of the chromatoplates in a manner such that the drop becomes as small as practicable, and then dries up. The smaller the diameter of the spot the better is the resolution. 5-10 microgram is sufficient for one operation. Substances are usually applied about 2 cm. from one side of the plate.

The plates are then put in the chromatography chamber, usually much smaller than paper chromatography chamber. The chamber should be saturated with the solvent vapour sufficiently ahead of the actual operation. Its walls should be lined up with filter paper soaked with the solvent to maintain steady saturation inside the chamber. The solvent is put inside the chamber to a thickness of 1 cm. The spotted chromatoplates are developed by the ascending technique. The plates are held vertically inside the chamber. They can also be developed by the descending technique with certain modifications of the chamber. The development takes much less time than in case of paper chromatography. When the development is complete, the plates are taken out and allowed to dry in air inside a clean, dust-free chamber at room temperature.

Detection of the movement of spots and determination of Rf values are similar to those in paper chromatography. Detection of spots can be made by spraying the chromatogram with visualizing reagents or in some cases it may be done by seeing the chromatogram in u.v. light.

Partition and ion exchange TLC can be performed in the same way. Two-dimensional thin-layer chromatography has also been achieved with success by developing the single plate in two directions at right angles to each other utilizing two different solvent systems. Thin-layer electrophoresis has shown good success in separation of mixtures of various types of compounds.

GOKULANANDA MAHAPATRA

Significance of antibiotics

THE discovery of antibiotics has been one of the landmarks in the history of medicine. An antibiotic is a chemical substance produced by the living organisms which demonstrates inhibitory or germicidal activity towards microorganisms *in vivo* or *in vitro.* When used in very minute quantities they inhibit growth of certain other microorganisms. They are now regarded as indispensable weapon in the medical armoury.

Most species producing antibiotics exist in nature in strains varying in their capacity to produce the antibioties. As requirements of antibiotics for treating man are high, the artificial synthesis of antibiotics is increasing day by day. But they should not produce undesirable reactions. They should be relatively non-toxic to phagocytes (an important defence mechanism of most metazoa). A green alga (*Chlorella*) is known to produce the antibiotic named "Killer". Some protozoans, e.g. certain strains of *Paramecium aurelia* are also known to produce antibiotics. The following are some of the important antibiotics.

Penicillin. The most important amongst the antibiotics is penicillin. Penicillin was discovered by Alexander Fleming in 1928. It is practically non-toxic to the body cells. Various species of the moulds, *Penicillium notatum* have been used for the production of penicillin. *Penicillium notatum,* and *P. chrysogenum* are specially favourable for the production of penicillin. In India, *P. chrysogenum* is employed by the Hindustan Antibiotics for the production of penicillin. It is soluble in water and is active against infection caused by moulds such as *Staphylococci, Streptococci, Pneumococci, Gonococci* and certain other gram-positive organisms. Certain other sources of penicillin are the strains of *Aspergillus flavous* and *Aspergillus gigantens.* Penicillin is also used for the prevention and treatment of infections such as bacterial endocarditis, carboroucles, dermatitis, emphyema pneumonia, gonorrhoea, syphilis, styes, pimples, healing in burns and abscesses, etc. The use of penicillin for treatment of milch cows suffering from infectious mastitis results both in the alleviation of suffering and an increase in milk supply.

Streptomycin. It is another powerful antibiotic discovered by Waksman in 1943 from actinomycetes—a group of soil microorganisms enjoying intermediate position between fungi and bacteria. It is produced in large quantities from selected strains of *Streptomyces griseus.* Streptomycin is a wonderful antibiotic against tuberculosis. It is particularly effective against urinary infections, bacteria, meningitis (inflammation of the linings of the brain) and other infections caused by *Hemophilus influenzae* and specially tularaemia. It is non-toxic to man. It cures pains, irritations, headache, fever, etc. It is known as a broad spectrum antibiotic because it is capable of destroying a wide range of microorganisms.

Chloromycetin. The first broad spectrum antibiotic chloromycetin, was discovered in 1947. It is effective against typhoid fever (enteric group of fever), whooping cough, bacillary dysentery and other intestinal diseases. This is produced by *Streptomyces venezuelae.* This antibiotic induces in the patient a false feeling of well being even before he is out of danger.

Terramycin. This is the second broad spectrum antibiotic discovered in 1950. It is obtained from *Streptomyces rimosus.* It is effective in infections like amoebic dysentery and African sleeping sickness —a disease caused by protozoans, *Trypanosomes.* Terramycin prevents the rapid spread of infections by susceptible organisms as it enables the body's defences to fight them. Terramycin speeds up the growth of pigs and facilitates egg-laying in hens.

Aureomycin. It is produced by *Streptomyces aureofaciens.* It is highly effective against both gram-positive and gram-negative bacteria. It is particularly used for treating bacterial eye infections, rickettsial and venereal diseases caused by viruses. Aureomycin has got a great penetrating power and therefore, is used against deep tissue infections. It is also used against Quench fever and Rocky mountain spotted fever. It has no toxic side effects.

Erythromycin. It is derived from *Streptomyces erythreus* and finds application in combatting infections caused by gram-positive pathogens which have developed resistance to the earlier discovered antibiotics.

Neomycin. It is a basic compound and most effective at an alkaline pH. It is soluble in water and insoluble in organic solvents. It is specially active against mycobacteria but not against fungal infections. It is also used as antiseptic.

Bacitracin. It is produced by a strain of *Bacillus subtilis.* It is effective against *gonococci* and gram-negative organisms.

Ilotycin. It is a new wide range crystalline antibiotic showing activity against most gram-positive and gram-negative bacterial infections.

Tyrothricin. It is produced by *Bacillus brevis* and is widely used in the preparation of medicated bandages. It is effective in respiratory infections.

Polymyxin. It is produced by *Bacillus polymyxa* and is employed in combatting infections of the blue pus caused by *Pseudomonas aeruginosus.*

Adriamycin. This antibiotic is used in acute leukaemia. Adriamycin, first isolated in 1967 from *Streptomyces peucetius*, is a water soluble, red crystalline solid. The antibiotic is either given in vials containing 20 mg or by intravenous injection along with cytosine arabinoside. Even a very small quantity of penicillin, aureomycin or terramycin when added to a rice diet improves the quality of the diet. Penicillin has been found to be effective in pest control. Antibiotics are used in animal husbandry as feed additives to enhance fattening of food animals. They are used by food processors to lessen spoilage of poultry fish and vegetables.

DAYA RAM SINGH

Feed-back—the mechanism of auto-regulation

ENDOCRINE secretions play a prominent part in regulating cellular metabolic functions and controlling physiological responses of the organism. Human body is often subjected to environmental disturbances but is able to cope with them. What ensure these adaptive reactions are the hormones. Hormone secretions are however subject to control mechanisms. There are a host of intricate balancing mechanisms that start working as soon as fluctuations occur. In most cases, these tasks are performed by an integration of nervous and hormonal mechanisms. These two systems coordinate and integrate the operation of other systems in the body and bring about adjustments to meet the environmental changes.

In 1930 the concept of reciprocal pituitary-gonad axis was first formulated. The term "feed-back", frequent in the language of cybernetics, was used to explain this phenomenon. It is defined as "transferring some of the energy from the output circuit of an amplifier back into the input circuit". The feed-back may be negative or positive depending upon whether the phase of feed-back signal is out of phase or in phase with the input signal.

Negative feed-back is a control

mechanism for hormone secretion particularly of pituitary trophic hormones to peripheral hormone levels. The products of pituitary trophic hormones, viz., cortisol, thyroxine and gonadal steroids feed-back on the hypothalamus and pituitary depressing the secretion of pituitary trophic hormones. Similarly parathyroid hormones and insulin are secreted in accordance with negative feed-back for serum calcium and blood glucose levels. Negative feed-back sometimes involves more than one action of feed-back hormone, e.g. estradiol inhibits secretion of FSH (follicle stimulating hormone) and stimulates release of LH (leutinising hormone).

In positive feed-back the hormone stimulates further events leading to its own secretion. It is less common compared to negative feed-back. The best example for positive feed-back is the relation between estradiol and LH release before ovulation. Since positive feed-back may lead to serious consequences its occurrence in the system is rare.

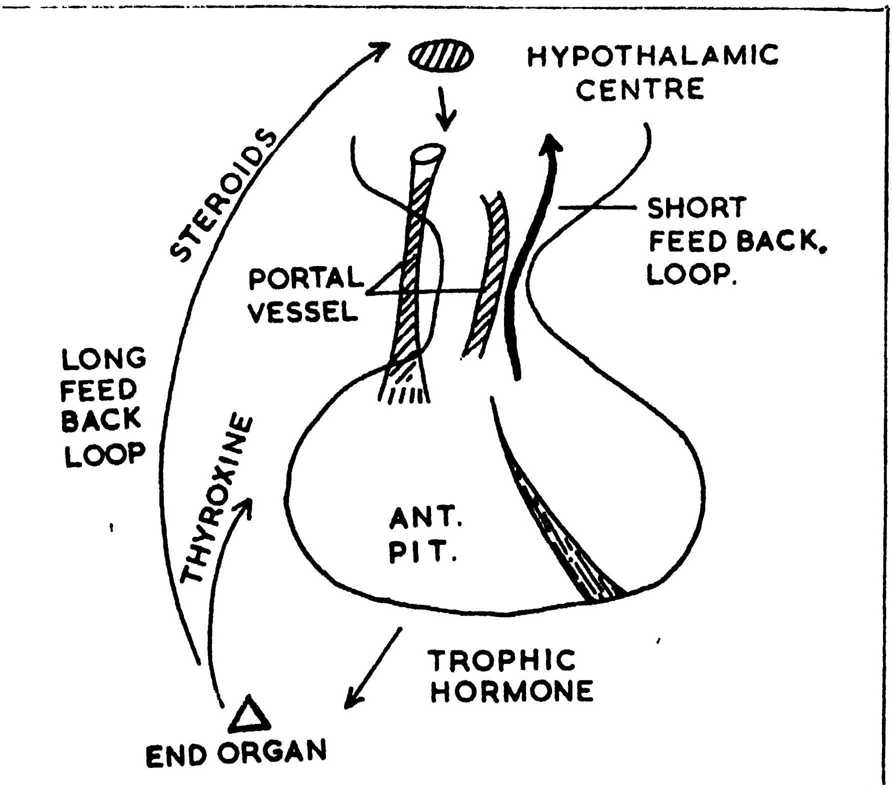


Fig. 2. Control of anterior pituitary function

Negative feed-back control of pituitary function

The reciprocal relation betwee.. pars distalis of the pituitary and the target organs regulated by trophic hormones (gonads, thyroid and adrenal cortex) is a remarkable example of homeostatic mechanism. The relationship is to achieve a sustained level of target organ hormone to meet the requirements of the organism. If a change in physiological conditions results in increased utilization of a target organ hormone, the blood level falls and the pituitary responds by increased trophic hormone secretion until the normal blood level is maintained. Administration of exogenous target organ hormone will inhibit trophic hormone production. The feed-back inhibition by target organ hormones evidently is exerted by an action both on the hypothalamus and on pituitary itself.

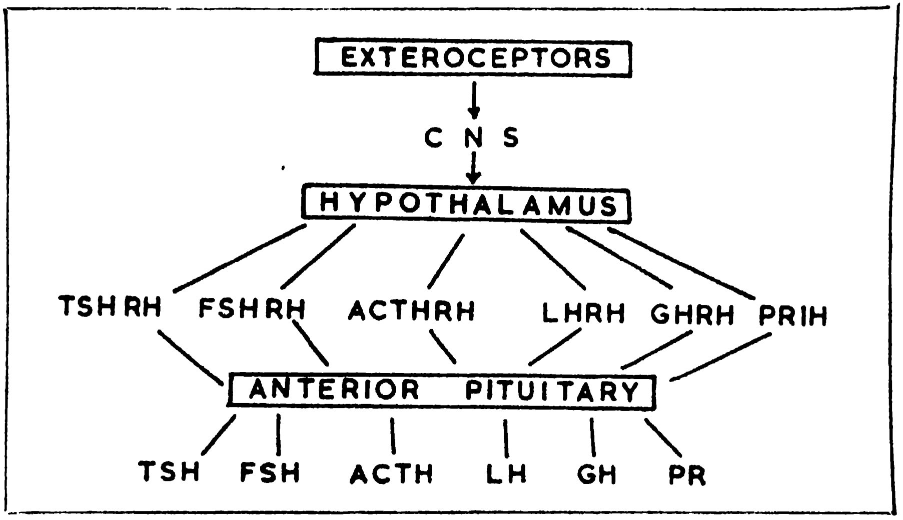


Fig. 1. The environmental influences on hypothalamus and pituitary to maintain homeostasis

There is now evidence that in mammals, birds and amphibians the central nervous system, via hypothalamic centres, controls the release of corticotrophin, gonadotrophin and thyrotrophin hormones from pars distalis. This control is mediated by hormones which are liberated in the median eminence of the neurohypophysis and transported through portal vessels to pars distalis. Such hormones are called release hormones. The secretion of LTH alone is however under the inhibitory control of the hypothalamus, and the factor inhibiting LTH may be the same which stimulates release of FSH or LH.

The hormonal and nervous interplay can be explained with an example. If the blood thyroxine level falls below the needs of the body, circulating hormones stimulate the hypothalamus release hormones which activate TSH secretion in the anterior pituitary. This obviously increases the thyroxine synthesis by thyroid gland. If, on the other hand, the thyroxine level in the blood is greater than required for normal metabolism, it inhibits the hypothalamic release hormones and the entire process is reversed (Fig. 1.) There is no clear-cut feed-back control system for growth hormone apart from the inhibiting effect of glucose on growth hormone release via the hypothalamus.

Besides the long feed-back loop involving peripheral hormones or metabolic factors, there are also short feed-back loops by which pituitary hormones can reflexly modify their own rate of secretion by acting back directly upon the hypothalamus. (Fig. 2.)

There is evidence for autoregulation of ACTH, LH and FSH and also probably for GH and MSH. A short loop control system could prevent wide variations in trophic hormone secretion whereas the long loop feed-back by peripheral hormones would adjust the overall secretion rates according to metabolic demands and reproductive rhythm. A possible role is played by short portal vessels which might carry a sample of pituitary blood back to pituitary stalk and adjacent hypothalamus. Small quantities of ACTH, LH and FSH have been detected in hypothalamic extracts.

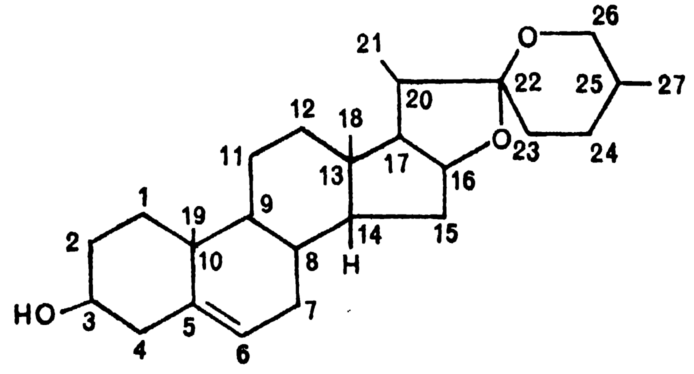
Another classical example of negative feed-back is the relationship between pituitary and adrenal cortex in mammals. The negative feed-back relation between progesterone and LH is evidently real and has helped make the "pill" for oral contraception. This is because progesterone inhibits gonadotrophin-release hormone of hypothalamus. As a result, gonadotrophins from the pituitary are not secreted and the ovulation is prevented. This negative feed-back has a practical implication in family planning. The interaction of hormone and brain functions co-ordinates pituitary-gonad activity with the appropriate sexual behaviour for fertilization, maintaining pregnancy and providing necessary mechanism for lactation.

SWAMINATHA KASINATHAN

Diosgenin from tuber crops

TUBER crops offer great scope for solving the problem of food scarcity particularly that of starchy foods. Besides, they have great potentialities for being used in the synthesis of drugs and pharmaceuticals. Yam (*Dioscorea* species), one of the less known tuber crops, is of commercial importance for its diosgenin content. During the mid-fifties of this century, it was discovered that certain species of Dioscorea contained diosgenin in appreciable amounts. Since then, they have replaced the animal sources like bile, for the manufacture of various steroid hormones. The principal diosgenin producing countries are Mexico, Guatemala, India and China.

Diosgenin, the sapogenin most widely used in the synthesis of steroid drugs, was first discovered in 1936 in Japan. That discovery lay dormant for some years. In 1940 R.E. Marker and his associates of the Meijo University, Nagoyo, Japan revealed the potential uses of plant sapogenins for the synthesis of cortisone and other drugs. After



. Diosgenin

World War II, the growing need for steroid drugs and the high cost of obtaining the same from animal sources led to a widespread search for plant sources of animal sapogenin. The intensive search by botanists coupled with that of chemists resulted in isolating diosgenin from *Dioscorea* species. The *Dioscorea* genus, though found predominently in the tropics and subtropics, is widely distributed all through the world. The plants have twining annual stems arising from underground or partly underground tubers. It is from these tubers that diosgenin is obtained. The plants are dioecious and bear sprays of very small and often inconspicuous flowers. The leaves are distinctly parallel-veined.

Cortisone, one of the adrenal hormones of animals, is of great value in treating skin disorders, eye infections, blood diseases and endocrine disorders as well as rheumatoid diseases. Now-a-days most crotisone is made from diosgenin extracted from dioscorea. The C 27 steroidal sapogenin, diosgenin (1) (A5, 25 α-spirostan-3β-ol.) is of considerable economic importance to the pharmaceutical industry in the synthesis of oral contraceptives, sex hormones and other clinically useful steroids.

Table 2

Species	*Desirable characteristics*	*Undesirable characteristics*	*Peak flowering period*	*Fruit maturity in days*
D. alata	Very high yielding (10-15 lb tubers/plant year)	No diosgenin	Sept-Oct.	—
D. deltoidea	Tubers contain high contents of diosgenin in pure form	Weak growth, low tuber yields.	March-April •	90
D. florifunda	Vigorous—high yield—moderately high in diosgenin	Deep tubers, late sprouting	Sep-Oct.	110
D. composita	Vigorous—moderate yield and diosgenin content	Dormancy present, deep tuber	Aug.-Oct.	120
D. friedrichsthalli	Vigorous—moderately high in sapogenin	Relatively low in yield	Sept.-Oct.	110

Out of 800 known species under *Dioscorea*, only 15 species are known to contain steroidal sapogenins. In India, two species, viz., *D. deltoidea* from North Western Himalayas and *D. prazeri* from North Eastern Himalayas have been principally used for diosgenin extraction. Some of the species of *Dioscorea* rich in sapogenin content are given in Table 1.

The underground storage organs containing starch and sapogenin develop from stem tissues and increase in size predominantly by gorwth of their dorsal side. Sapogenin content of wild tubers ranges from 0.8 to 15.0 per cent of the dry matter. The size of these tubers and their sapogenin content varies considerably with the plants depending upon the age and conditions of growth. Decreases in sapogenin content during spring growth and increases in summer and fall have also been observed. Diosgenin content also varies with the different portions of the tuber. The content is more in the dorsal portion than the ventral portion in in *D. deltoidea* and *D. composita* on fresh weight basis. However, in *D. florifunda* the ventral portion has relatively more diosgenin than the dorsal. The tip portion in *D. composita*, the medium portion in *D. florifunda* and portions without sprouted buds in *D. deltoidea* have relatively higher diosgenin on fresh weight basis.

Table 1

	Name of the species	*Probable geographic sources*	*Highest known % of sapogenin*
1.	*D. balcanica* Kosanin	Europe	2.0
2.	*D. belizensis* Lundall	British Honduras	2.6
3.	*D. colletti* Hookf	China	2.0
4.	*D. composita* Hemsl.	Mexico	13.0
5.	*D. deltoidea* Wall.	India	8.0
6.	*D. florifunda* Mert & Gal.	Mexico, Central America	10.0
7.	*D. friedrichsthalii* Kunth	Costa Rica	4.0
8.	*D. nipponice* Mekino	Japan	2.0
9.	*D. panthaica* Prain & Burk.	China	2.0
10.	*D. prazeri* Prain and Burk.	India	2.1
11.	*D. prazeri* var. glauca	India	4.5
12.	*D. spiculiflora* Hemsl.	Mexico	15.0
13.	*D. sylustica* Ecklon	South America	6.0

Among the different species of *Dioscorea*, only some have scope for sapogenin extraction. Right amount of fertilizers, optimum spacing and supports for the vines for proper growth are essential requisites for high sapogenin content. The desirable growth characteristics of five species of *Dioscorea* are furnished in Table 2.

A. SHANMUGAM
R. SUBBIAH
C. SRINIVASAN

Hybrid wheat in baking industry

TO fight against the malnutrition, which has now been recognised as the single major malady threatening the health of our nation, soyabean and maize have been discussed at length because of their high amounts of portein and lysine contents. Soyabean has been recommended as a supplement to milk as it contains 38 to 42 per cent proteins with balanced proportion of amino acids. Possibilities of preparing other products from soyabean, e.g., artificial meat, oil, flour, medicines, etc., can also be rated high. Shakti and Protina varieties of maize have also been discussed widely and are now being given to school children as breakfast and meals. Wheat, however, has not got its due share in the programme because the wheat varieties in India are not very rich in proteins and also lack good baking qualities.

During the past decade, spectacular success has been achieved in evolving wheat varieties with high yield potential. Some of these high yielding dwarf wheat varieties do contain a satisfactory level of protein but are not good in bread making qualities. In India wheat is used largely for making *chapatis.* White or amber grains, medium large to bold in size, with hard vitreous texture and lustrous appearance appeal to the consumer and are given preference. However, for baking industry it is important that wheat milled into flour and baked into bread possess those milling and baking qualities that will result in the production of a uniform flour and finally a uniform and acceptable loaf of bread. Because of the poor baking qualities and low protein content in the available wheat varieties, India is dependent on other countries like Australia, Canada and the United States of America for significant quantity of wheat imports to feed the baking industry. Further, as the economy of our country advances, there is likely to be greater utilization of wheat for baking bread than at present. Keeping in view this problem, the breeders should evolve some wheat varieties that have both a high protein content as well as the desired baking properties as the wheat being imported for the baking industry. 'Hybrid wheat' seems to be an obvious answer as the reports indicate a higher protein content and better baking qualities in hybrid wheat than the conventional wheat cultivars. Triticale—the first man made species, could also be considered because of high protein content but it cannot be grown due to certain other handicaps.

Table 2. Superiority of hybrid wheat over the wheat variety Kalyan Sona (after Singh and Sindhu, 1972)

Hybrid Wheats		*Yield in gm per plant*	*Percentage of yield superiority over Kalyan Sona*
Kalyan Sona		50.26	Standard variety
Hybrid No.	1	81.24	61.63
,,	2	71.54	42.50
,,	3	62.04	23.43
,,	4	76.22	51.65
,,	5	96.27	91.54
,,	6	75.29	49.80

Table 1. Bread baking characteristics of wheat cultivars

	Flour protein %	*Ash*	*Mixograph*		*Loaf characteristics*			
			Time in minutes	*Relative tolerance of mixing*	*External*	*Grain*	*Texture*	*Volume*
Bison	12.3	0.428	3½	2	VG	G	VG	980
Bison × NBR 3547	13.8	0.740	2¾	2	VG	G	VG	1000
Gage	12.1	0.378	2⅝	3—	G+	VG	VG	925
Gage × NB 3547	13.9	0.570	2¾	2+	VG	VG	VG	960
Gage × NBR 3547	13.8	0.156	3½	3	VG	G+	VG	985

Researches on hybrid wheat have revealed that it has richer protein content than its parents. Schmidt and his associates (1970) have reported that the male sterile lines have a higher protein content than their maintainers. This obvious increase in protein content could be well assigned to the male sterile cytoplasm.

Hybrids from male sterile lines contain still higher protein if the restorer line used is also rich. Hybrid wheat researches conducted at the Meerut University indicate that in some of the hybrids the protein content was as high as 18.3 per cent. This can be further increased by supplying higher doses of nitrogen fertilizers to hybrid wheat crop. As compared to Indian wheat varieties, which on an average contain 10-14 per cent protein, this is much higher and is also higher than the wheat being imported for the baking industry. Results of other baking characteristics are also quite encouraging.

As regards the yield potential

there is no controversy about the high yields of hybrid wheats. Superiority of hybrid wheat yields over the conventional wheat varieties is very well established. In Table 2 the superiority of hybrid wheat yields over Kalyan Sona, the highest yielding wheat variety so far in India, has been shown.

There could be one point to be taken into account before we go for the commercial cultivation of hybrid wheat. Will it be economic to grow hybrid wheat? This question arises because of low percentage of seed set by outcrossing on male sterile wheat lines and also because of the fertility restoration system being very susceptible to the changed environments. During the last several years of research in India an answer to this problem has been obtained. A stable fertility restoration system has been established and some male sterile lines have been developed in which natural outcrossing is as high as 80 per cent. The hybrids produced from these lines besides having nearly 18 per cent protein are good in bread baking characteristics. Some bigger experiments for the commercial exploitation are being planned. However, even if it is not economical to grow hybrid wheat in comparison to conventional wheat cultivars, we should not overlook the other aspect of it, viz, substitution of wheat imports. Hard earned foreign exchange that is being spent for wheat imports for baking industry could be utilised for some still more important purposes.

JAGVEER S. SINDHU

Sex in bacteria

THE main method of reproduction among living beings is sexual reproduction. In the higher organisms it is the only method. In lower forms of life, sexual reproduction is rare. Bacteria are such organisms in which the main method of reproduction is by cell division. However, recent work has shown that sex does exist in bacteria, though there are no visible parts to perform this function. Bacteria have been very useful in the study of genetics, i.e., the science of heredity. Sexual reproduction in bacteria occurs through a process called conjugation. This process was first discovered by J. Lederberg and E.L. Tatum in 1946 while working in the Department of Botany at Yale University, U.S.A. When these investigators plated on minimal medium a mixed population of two *E. Coli* mutants having different nutritional requirements, they observed the appearance of colonies which had no growth factor requirements. It showed that recombination had occurred between the two strains. Later, it was observed that, of the two parents only one had the ability to transfer its genetic character (DNA) into the other.

Conjugation, therefore, may be defined as a process where recombination occurs by the one-way passage of genetic material from the donor to the recipient bacterium. Process of conjugation consists of two stages, the first one is concerned with the transfer of genetic material from the donor to the recipient and the second one is concerned with recombination and expression of the recombinant character in the bacterium. Electron microscopic studies have revealed that a tube or bridge is formed between the mating cells through which the genetic material is passed from one to the other.

The donor possesses an extrachromosomal particle called F (or sex factor) which determines its mating with the recipient which lacks this factor. Crosses between cells lacking F (F^-) do not occur, whereas cells having F factor (F^+) can be made to mate easily with F^- cells. They can, however, also mate with F^+ cells but the frequency with which they do so is very poor.

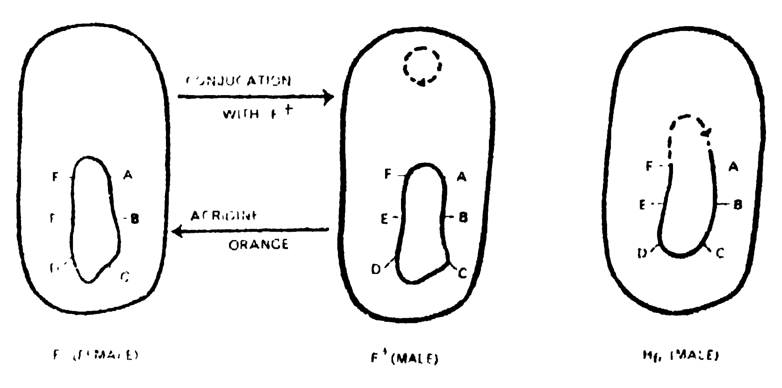


Fig. 1. F−, F+ and Hfr strains in the bacterium *E. coli*. ABCDEF are a number of genes located on the bacterial chromosome. Dotted line represents the sex factor, and arrow head indicates polarity of transfer of the chromosome from the male to female during the process of conjugation

F^+ cells also have the ability to transfer F factor into recipient (F^- cells) thereby making the F^- recipients into F^+ donors. This can only be done by cell-to-cell contact. Extracts of F^+ cells are unable to accomplish this feat. The segregant population after the conjugation process and the transfer of genetical material in part or whole turns into F^+ population. F^+ donors on treatment with acridine orange lose this factor and thereby are converted back to F^- recipients. The donor state could also get lost spontaneously or through irradiation. The donor condition once lost cannot be recovered spontaneously. The only way in which it can be brought back to the previous state is by conjugation with a donor. The F factor thus behaves as the genetic determinant for the donor character, and is also capable of self-replication. It is situated outside the original bacterial chromosome. In other words, it is a supernumerary chromosome more or less of the same size as the genome of a phage particle. The F factor possesses the ability of initiating at a low frequency the transfer of chromosomal markers randomly.

Another donor type can arise from F^+ cells. This is capable of transferring chromosomal markers at a very high frequency and is called Hfr. Hfr can revert to F^+ form showing that F^+ is retained in Hfr in some tightly bound or concealed form. The recombinants formed after mating between F^+ and F^- cells are all invariably F^+ (males), whereas in mating between Hfr and F^- cells the recombinants are F^-, only very minute portions are of Hfr type. Hfr donors unlike F^+ donors do not transfer randomly the chromosome of the donor strain but they transfer particular segment from the donor chromosome. Treatment of F^+ cells with acridine orange results in the loss of F^+ factor while Hfr is not affected. The changeover from F^+ to Hfr seems to occur by the insertion of the sex factor F present in the cytoplasm at one of the many sites of the circular chromosome of the bacteria. It is now an established fact that this insertion occurs through a recombination event between the circular sex factor and the circular chromosome (Fig. 1). At the time of conjugation the circular chromosome from the donor (male) opens at the site of sex factor insertion and gets transferred to the recipient (female) as a linear structure. After conjugation, the cells get separated and recombination takes place between the donor genes injected and the genes present in the chromosome of the recipient bacteria. This gives rise to a daughter cell bearing new combinations of the two parental characters. These new combinations are transmitted to future generations.

AJIT K. MISHRA

Food preservation by irradiation

THE question of food preservation by ionising radiation has been the subject of extensive research in a number of countries for some years. Technologically a large number of applications of ionising radiations are advantageous; irradiation could substitute a number of alternative traditional methods of food preservation and could cope with a number of special problems which cannot be solved by older procedures.

The absence or inadequacy of alternate technologies for food preservation on a large scale confers special advantages in the adoption of food irradiation. The cost of putting up an irradiator and operating it would compare favourably with that of constructing a food freezer plant and its associated chain of frozen storage, transportation and retailing facilities extending from processor to consumer. Apart from the fact that not all foods are amenable to canning, the economics of the method is limited to the availability of the low cost tin plate containers. At present such packaging material is scarce and expensive and the cost of the container often forms a major portion of the price of the product. Dehydration is also of limited applicability, especially as it severely restricts the end use of the product. It would therefore appear to be cheaper and easier to introduce food irradiation than any of the other established food preservation methods.

The radioisotopes emit spontaneously radiations of three types which are called alpha, beta and gamma rays according to their particular properties. Radioisotopes now-a-days are employed in many fields of industry, agriculture, medicine, etc. Gamma radiation in large enough doses can destroy bacteria and enzymes in a material without significantly raising its temperature. The recent availability of large sources of irradiation has increased interest in radiation sterilisation and has increased the feasibility in irradiation treatment of foods and pharmaceuticals. Large-scale sterilisation and pasteurisation of perishable food stuffs such as meats, potatoes and beverages hold interesting possibilities.

Radiation inhibition of sprouting of soybeans is applicable for a new purpose. Irradiation of soybeans in the process of germination results in the reduction of the oligosaccharide content of the beans leading to a product which does not cause the well-known phenomenon of flatulence (excessive gas formation in the intestines of man after eating beans), at the same time faster cooking soybeans can be produced in this way.

Regarding potatoes, onions and garlic, the major benefits are three fold—present day losses in cold storage (4° C potatoes and 0° C for onions) as well as in marketing channels and in homes can be reduced; the products have a better look, have a better texture and taste better than the conventionally cold-stored products. Furthermore, the shelf life at the green grocer's and at home is considerably extended as there is no sprouting. With citrus fruits the same fungicidal control can be attained as is currently obtained by wrapping the fruit with diphenyl paper.

Special importance should be assigned to the radiation disinfestation of fresh fruits and vegetables for quarantine purposes, that is, to facilitate inter-country trade of fruits without the risk of infesting the importing country with dangerous insects inhabiting the fruits. Elimination of insect damage in a number of food items has been successfully achieved after many research programmes on food irradiation in laboratories of various countries. According to this confirmation, the radiation disinfestation is a highly practical proposition to control insects in grain, flour, peanuts, walnuts, dried fruits, etc.

In the case of starch irradiation, where pasteurisation is the aim, the anticipated benefit is the elimination of taste, colour and nutritional changes occasioned in the heat sterilisation. In comparison with alternative technical methods of disinfestation, radiation offers the advantage of eliminating harmful residues. The microbicidal action of radiation was found to remarkably improve the quality of maize starch preparations, thus improving the hygienic characteristics of foods prepared with starch. The same was observed for mixed seasonings and paprika powder.

Irradiation sterilisation can be used successfully to store ham, bacon, pork, pork sausage, beef, canned beef, chicken, cod fish cakes and shrimp for long periods under non-refrigerated conditions. The technical feasibility of using ionising radiations to preserve such highly perishable protein foods has been proven under US Army Radiation Preservation of Foods Programme and the technology is far enough advanced to carry out this.

In recent days the technology of radiation processing has advanced much in the aspects of selection of radiation source, irradiation in frozen states, use of 12-D dose (dose required to reduce the number of micro-organisms per gram to 10^{-12} of the original number present) for destruction of *clostridium*. Meat products prepared with irradiated spices had to be heated less and kept longer than those contaminated by the high bacteria content of the non-treated spices. It has been seen that irradiation of Wiener sausages and of a Japanese fish-paste product called karuaboled, along with heat treatment, prolonged storage stability considerably. High dose radiation sterilisation of meat, meat products and poultry is a practical possibility if it is combined with a mild treatment to inactivate radiation resistant proteolytic enzymes of the tissues. Products of practically unlimited shelf-life can be produced, for example, without the necessity of using refrigeration.

There is no problem in the irradiation of tinplate at doses upto 7.5 mega rads at temperatures as low as -90°C, provided the can enamels used are of the epoxy-phenolic or phenolic types and the end sealling compounds are of the butadiene-styrene or neoprene types. Four food contacting plastic films are being used as components of flexible packaging in the form of pouch laminates with aluminium foil as the gas, water vapour and light barrier. The most favourable balance of quality, cost and required irradiation dose appears at about -30 ± 10 °C. Vitamin losses during preparation for eating will be negligible regardless of the prior treatment.

Safety for consumption is the other main and important point which has been thoroughly studied. Newer protocols, based on the most recent technological procedures, are therefore currently being used by the US Army to evaluate the safety of radiation sterilised foods. The question of toxicity is not unique to the irradiated foods only, but is one which should be considered for all substances including all processes to which food is subjected.

The possibilities of using radiation for food preservation as a way of making up food deficiency in the world are obvious.

K. VENKATA RAMANIAH

NEWS & NOTES

Second Hooker Award to a rice breeder

THE Second Hooker Award for Agricultural Research leading to increase in food production, for the year 1972, has been awarded to Shri M.J. Balakrishna Rao, Geneticist and Botanist, Central Rice Research Institute, Cuttack.

The donors of the Award are the late Mr. and Mrs. Richard Hooker of Longmeadow, Massachusetts, U.S.A. The purpose of the Award is to create incentive for research workers of India to help in the process of improving food conditions in India. The Award is made for either fundamental research or applied research including inventions, discoveries, etc., leading to significant results of practical value in the field of agricultural production.

The prize is of a value of Rs. 2000/- in cash or kind or both along with a scroll honouring the scientist for outstanding research in any field or subject within the purview of research in agriculture, animal husbandry and fisheries.

The Hooker Award has been offered to Shri Balakrishna Rao in recognition of his outstanding contributions in the field of breeding new high-yielding rice varieties in India. The rice varieties CR-1014, *Padma*, *Bala* and *Krishna* have been evolved by him. He was associated with Shri K. Srinivasulu in evolving cold-tolerant cultures *Kalinga-I* and *Kalinga-II* which were released recently.

Shri Rao is at present engaged in the development of medium tall varieties suitable for Kharif season and also in an *indica* × *japonica* hybridization project in which a few high-yielding rice cultures have given outstanding results in Kashmir, etc., and a few others have been very promising in Uttar Pradesh. Some of his *indica* × *japonica* cultures in addition to the high-yielding potential have resistance to pests like brown plant hoppers.

R.K. JAIN

Nobelist Dr. Sutherland Jr. passes away

DR. Earl W. Sutherland Jr., who discovered cyclic AMP (adenosine monophosphate) and its fundamental role as a second messenger in hormone action, died in Miami on March 9, 1974 after having undergone surgery for internal bleeding. He was a member of the faculty of Miami's Medical School (since July, 1973) and was 58 years old at the time of his death. He won the 1971 Nobel Prize in Physiology or Medicine (see *S.R.* November, 1971) for his basic research on hormones and cyclic AMP, a work he carried out during the last 20 years. It was the first time in the decade that the Nobel Prize in Physiology or Medicine was not shared, because, "very seldom can a discovery be credited to a single person", a member of the Nobel Award Committee remarked at his prize winning. Until recently, the mechanism by which hormones exert their important functions had been a mystery. Because of Dr. Sutherland's elucidation it is now easy to understand the general mode of action of many hormones. Through a series of brilliantly designed and carefully controlled experiments he discovered a new chemical intermediary and showed that it participates in a wide range of biochemical and physiological control and regulatory mechanisms. His discovery opened up new research in diabetes, cancer, and other diseases, and cyclic AMP and its derivatives are now being used therapeutically.

Born at Burlingame, Kansas, (U.S.A.) on November 19, 1915, young Sutherland, received his medical degree from St. Louis' Washington University in 1942. He started his career as an assistant pharmacologist at the same University (1942-45), later becoming its Instructor of Pharmacology (1945-46) and of Biochemistry (1946-50), Assistant Professor (1950-52) and Associate Professor (1952-53). Later he moved to Cleveland's Western Reserve University School of Medicine as a Professor and Director of its Department of Physiology (1953-63). During 1963-73 he was the Professor of Physiology at the School of Medicine of Vanderbilteg University at Nashville. He received the Lasker Award of Basic Medical Research in 1970.

BHAKTI DATTA

MEDICAL NOTES

Human amoebic liver abscess

SEVERAL species of amoebae are known to habitate human intestine, but most of them are not considered pathogens. Only the large race of *Entamoeba histolytica* is potentially pathogenic as it attacks mucosa of the large intestine and is sometimes responsible for fulminating amoebic dysentery. It is equally pathogenic to laboratory animals. Other species of amoebae generally found in human intestinal tract are: *E. hartmanni*, *E. coli*, *Endolimax nana*, *Dientamoeba fragilis* and *Iodamoeba butschlii.* They are not disease producing and live as commensals in the lumen and feed on intestinal bacteria. In addition, *Entamoeba polecki* which is an inhabitant of pig intestine has been found in some human fecal samples. Persons carrying *E. histolytica* infection in the intestine may show symptoms of acute amoebic dysentery and pass blood and mucus in the stool, or show no symptoms although they sometime pass large number of cysts in the stool. The cysts are protected by a resistant cyst-wall and remain viable under moist conditions. Infection spreads to healthy persons when they swallow the mature (4 nucleate) cysts with food or drinking water. These cysts open up in the large intestine and give rise to amoebae (trophozoites) which start multiplying by feeding on bacteria, and, later, attack intestinal mucosa. Surveys conducted so far have shown that the incidence of amoebiasis ranges from 3.8 to more than 50 per cent in various parts of India.

Human infection with *E. histolytica* does not remain restricted to the intestinal tract but spreads to other organs as well. This is due to the migration of trophozoites of *E. histolytica* from the ulcers in intestinal wall to liver and other organs through the blood stream. In most cases the amoebic abscess develops first in the liver. This condition is called hepatic amoebiasis. From the liver the amoebae occasionally spread to diaphragm, lungs, pericardium, spleen, peritoneal cavity or even brain, where they establish new foci of amoebic infection. The size of amoebic liver abscess may range from a barely discernible 1 mm to 20 cm in diameter cavity. Chocolate coloured pus is generally present in large quantities in the abscess which can be aspirated surgically. Motile amoebae are usually found in the wall of the abscess rather than in the pus. The pus from the abscess is generally bacteriologically sterile, suggesting that amoebae which migrate from the intestinal tract to the liver are able to establish and colonize in the liver tissue without any bacterial associates.

Symptoms

In many cases the hepatic abscess may develop in the absence of any intestinal symptoms. The abscess is generally localized in the right lobe of the liver rather than the left lobe and it may be single or multiple. The right-sided abscess develops due to the fact that portal circulation which collects the blood from colon, where most amoebic ulcers are located, goes first to the right lobe where amoebae would have greater chance of colonizing. Anderson, Bostick and Johnstone (1953) have reported that 4-5 per cent of the cases recorded in America suffering from amoebic dysentery show amoebic liver abscess. They found nearly 28 per cent cases showing liver abscess among the fatal cases. The liver abscess is more common in males than in females.

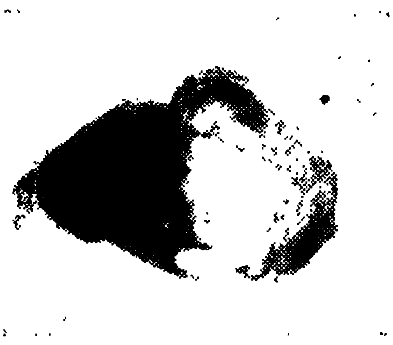


Fig. 1. Amoebic abscess in hamster liver

The main symptoms of the amoebic liver abscess are palpable and highly enlarged liver, pain in the right costal margin and occasionally in right shoulder, temperature and "tenting" or raised diaphragm as shown by fluoroscopic screening. The technique of liver scanning with the help of Au-198 colloid scan has been recently developed for quick diagnosis of liver abscesses.

Treatment

It must be emphasised that all cases of hepatic amoebiasis also carry intestinal or bowel infection. In cases of intestinal amoebiasis, on the other hand, the infection may remain localised to bowel lumen and wall, or also spread to extra-intestinal sites like liver. The amoebicidal drugs commonly used are selective in their action with regard to the site of infection. Some drugs like Diiodoquin, Vioform, Chiniofon, and Carbarsone are considered as direct acting luminal amoebicides because they can kill the amoebae on contact, in the bowel lumen. Other drugs like emetine hydrochloride, emetine and bismuth iodide, and dehydroemetine are regarded as direct acting tissue amoebicides because they are absorbed from the intestinal tract and are, therefore, capable of destroying amoebae in the intestinal tissues, liver and other organs. Chloroquine is another tissue amoebicide which is active only in the liver. Metronidazole (Flagyl) acts on the amoebae at all sites. It is, therefore, considered as both luminal and tissue amoebicide. It is, practically possible to cure the trophozoite infection with single or a combination of the above luminal and tissue amoebicides. However, cases of chronic and asymptomatic nature who pass cysts in their stools cannot be easily cured because the available antiamoebic drugs have little or no effect on the cysts (Rees, 1955). In cases of hepatic amoebiasis specific therapy with systemically active amoebicides like emetine, dehydroemetine, chloroquine and metronidazole immediately leads to regression of abscess. Tenderness, enlargement of liver (*hepatomegaly*) and pain disappear within a few days. Treatment with these amoebicides combined with aspiration of pus provides complete cure for amoebic liver abscess. Generally there is no relapse. However, if the bowel infection is not completely eradicated, the liver abscess may develop again due to fresh migration of amoebae from the intestinal tract. For proper management of hepatic abscess it is therefore important to treat effectively both the intestinal and extra-intestinal sites of infection.

As in man, the experimental animals like cats, dogs and hamsters have also been reported to develop hepatic abscess after caecal or colonic infection with *E. histolytica*. Amoebae have been reported to migrate from intestinal ulcers and colonize in the liver and produce bacteria-free amoebic abscesses in liver. The percentage of hamsters developing liver abscess by the above method is low. In order to develop a suitable model for *in vivo* screening of potential and new antiamoebic agents against hepatic amoebiasis, it was necessary to develop a method for experimental production of hepatic abscess in laboratory animals which should give high infection rate. Although guinea-pigs, gerbils and mice have been reported to develop hepatic abscess, hamsters are by far the most commonly used for experimental production of hepatic amoebiasis (Fig. 1). Several methods have been reported from different laboratories for infecting hamsters with trophozoites *of E. histolytica*. A simple method of producing hepatic amoebiasis in hamster without opening the body cavity has been developed at Central Drug Research Institute which requires no post-operative stitching and at the same time gives high infection rate (Dutta, 1970). This method involves giving a small incision in the abdominal skin in the liver region and then inoculating through intact muculars layer nearly 50,000-1,00,000 live trophozoites of *E. histolytica* from culture. Hamsters inoculated by this method developed single or multiple hepatic abscesses in 4-6 days. The liver lesions when cultured or examined directly as fresh smear under the microscope show live, motile trophozoites. Liver abscess shows a large number of amoebae in section. When the hamsters were sacrificed at various intervals from 1-6 days post-infection, a series of developmental stages of liver abscess were observed and they have been described as hepatic lesion grades 1-4. This method of producing hepatic amoebiasis has been found to be very useful for screening the activity of new or potential amoebicides against hepatic amoebiasis. The development of a suitable laboratory model for testing the activity of new compounds forms the basis of finding new and more potent drugs for treatment of hepatic amoebiasis.

G. P. DUTTA

BOOK REVIEWS

(*Continued from page 208*)

ting point, etc., biasing of single-stage transistor circuits, and analysis of the expected performance of small and large signal-handling circuits have been discussed however, on the assumption that the reader has preliminary knowledge about passive introductory circuit theory.

Although, from the point of view of acquiring elementary basic knowledge in circuit properties of transistors the book may be quite useful, its publication as a first reprint after about a decade from its first publication in U.S., may render the publication of limited utility.

B.B. GHOSH

SCIENCE FOR THE YOUNG

The mysterious liquid helium

INSPITE of the fact that helium is a comparatively rare gas, our present knowledge of cryogenics is mostly due to researches made on liquid helium and its isotope. At temperatures around boiling point of liquid helium (4.2 K) many substances show unusual properties which are both of academic and industrial interests.

Kamerlin Onnes of Leyden University was the first to liquify helium in 1908. Since then various types of helium liquifiers have been developed and each has its own merits. Essentially, however, the principle is the same. Helium gas is compressed (which heats it), cooled through liquid air (101.15 K), then through liquid hydrogen (20 K) and is finally subjected to Joule-Thomson effect. By repeating this process the gas is ultimately liquified.

Once liquid helium is formed, it cannot be seen because it has a very low refractive index (1.0257), almost that of the gas. What one actually observes is a meniscus, marking the boundary between the liquid and the gas above it. To make the matter worse, this has to be observed through four thicknesses of glass, and one of liquid hydrogen/liquid nitrogen. Similarly, since solid helium is perfectly transparent, nothing particular can be seen. By pumping out the helium vapours (energy for work done in removing the vapours comes from liquid) liquid helium can be cooled down to 0.71 K. But solid helium is not formed till pressure is applied. Optimum conditions are 35 atmospheres at 2K. Again, that solid helium has formed can only be concluded by the fact that the tube containing helium gas gets blocked and by releasing the pressure it can be un-blocked. Helium cannot be solidified under its vapour pressure and therefore is liquid down to absolute zero.

Properties at low temperature

When vapours of helium are pumped out, the liquid boils off with plenty of bubbles coming out as usual. As the temperature reaches 2.18 K, bubbles stop completely but boiling goes on (of course, the level of liquid goes on decreasing continuously). Upto this temperature, which is called (λ) Lambda point, helium behaves normally. Below this, the liquid shows an abnormal property of superfluidity, i.e., the viscosity of the liquid becomes zero. The liquid helium at this temperature can flow through very fine capillaries, even through the space between a platinum wire and the pyrex glass in which it has been sealed. This property has been explained assuming that liquid helium is a mixture of two fluids, a normal fluid (*n*) and the super fluid (*s*). The percentage of both varies with temperature. Upto λ point, liquid helium is all *n* whereas at temperature 1 K it is all *s*.

These two fluids move independently within the liquid. A remarkable and interesting experiment can be performed popularly known as helium fountain (Fig. 2). The bent tube shown in the Figure contains a fine powder such as emery through which *s* can pass but not *n*. When light is allowed to shine

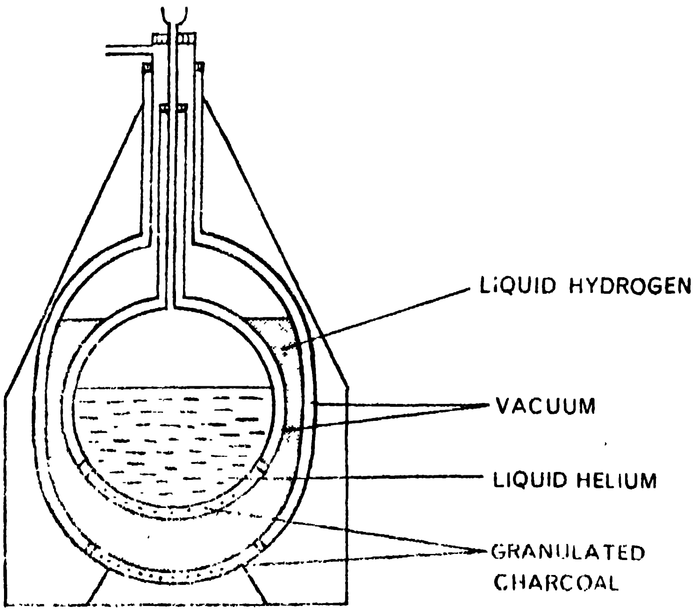


Fig. 1. Dewar flask for liquid helium

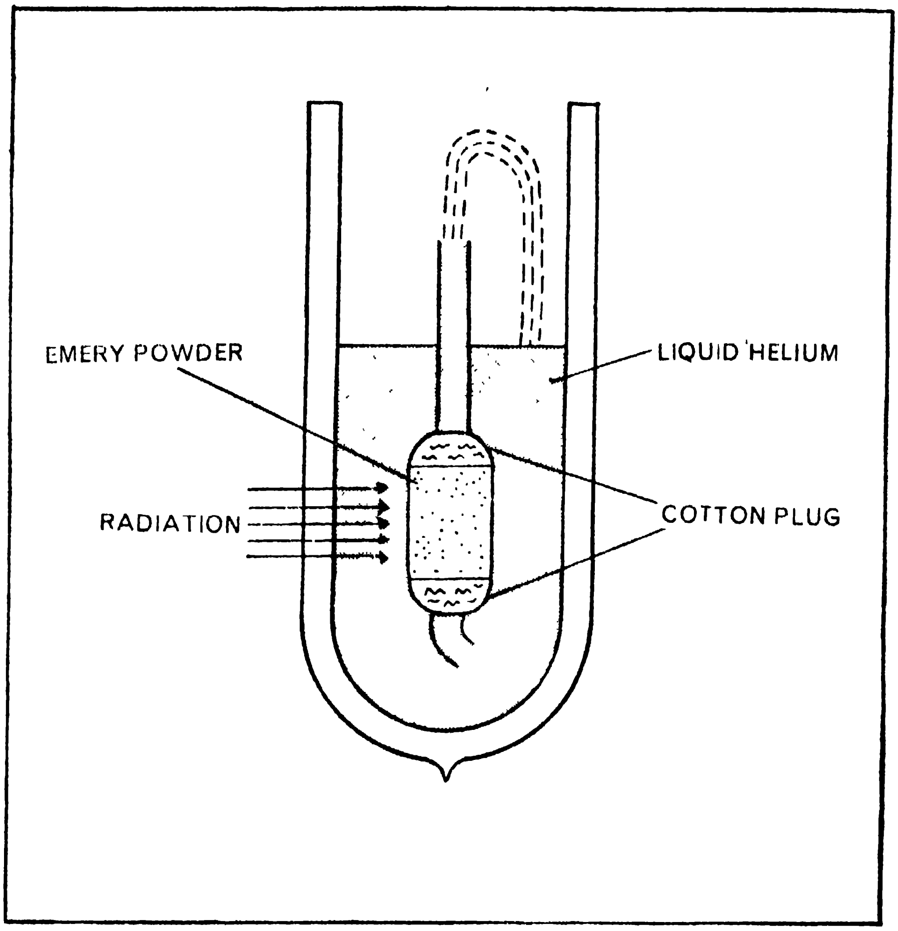


Fig. 2. Helium fountain effect

on the powder, liquid helium around this area becomes a little warmer (say 0.1 K) than the rest. Immediately helium .s rushes into the bent tube so quickly that it creeps up the capillary tube and is out from the top. This is a continuous process, forming a fountain which can be as much as a foot high.

Helium isotope ^{3}He

Isotope of helium having two protons and one neutron in the nucleus (normal helium has two protons and two neutrons) occurs to the extent of 14 atoms in every 100 millions in the helium found in oil wells. Atmospheric helium contains 120 atoms in 100 million of normal helium (^{4}He). With so poor a percentage it was impossible to make cryogenic studies with ^{3}He. But artificial radioactivity has now made it possible to make available enough of it. When lithium is bombarded with neutrons, helium and tritium (isotope of hydrogen) are formed. These can be separated by diffusion through red hot palladium. Pure tritium slowly decays to give ^{3}He and an electron.

Liquification has shown the boiling point of ^{3}He as 3.19 K, making it the most 'permanent' gas. Normal helium boils at 4.2 K. Even at a temperature of 100 K (that of liquid air) most of the organic materials like rubber tubes, plastics and even low carbon steel become brittle. But many substances show an extraordinary property known as superconductivity at the boiling point of liquid helium or below. Metals like mercury, tin, lead, etc., as well as numerous alloys and compounds such as certain nitrides and carbides, offer no or negligible resistance to the flow of electricity if kept at these temperatures. This property has been found very useful in industry in making electromagnets of very small size compared to conventional ones.

N. K. Agrawal

Table 1. Properties of helium isotopes

Physical property	*Helium (three)*	*Helium (four)*
Normal boiling point	3.195 K	4.216 K
Critical temperature	3.35 K	5.20 K
Critical pressure	890 mm Hg.	1711 mm Hg.
Critical density	0.0413 g/cc.	0.0693 g/cc.
Density of liquid at normal B.P.	0.059 g/cc.	0.1259 g/cc.
Density of liquid at 0K	0.082	0.145
Density of vapour at normal B.P.	0.024	0.016
Vapour pressure at 3K	618 mm Hg.	182 mm Hg.
2K	152	23.9
1K	8.68	0.122
0.8 K	2.8	0.011
0.05 K	0.15	0.000016
Latent heat of vaporisation at normal B.P.	11.3 cal g. at 2K	4.9 cal. g at 2K
Viscosity of liquid at normal B.P.	22 micropoise	26 micropoise
Viscosity of vapour at normal B.P.	12.5	11
Viscosity of vapour at 3K	12	7.5
2K	11	5

SCIENCE IN INDUSTRY

Extra-fine zinc dust

EXTRA-FINE zinc dust is a very fine powder of a mesh size of 325 and less. Its main use is as a reducing agent in the manufacture of sodium hydrosulphite. The requirements of zinc dust are almost entirely met by imports; more than 1500 tonnes of zinc dust were imported in 1970, involving a foreign exchange of about Rs. 5 million.

It has been estimated that more than 5000 tonnes of zinc dust will be required by the hydrosulphite industry alone on the basis of the plant capacities being set up. This indicates a large potential for the production of zinc dust indigenously. The National Metallurgical Laboratory (NML), Jamshedpur has developed the know-how for the production of zinc dust of 325 mesh and below to the required specifications (IS:4611-1967 and BS: 3982-1966). Preliminary cost estimates indicate an investment requirement of Rs. 15 lakh on equipment for a 3000 tonnes per annum production unit, with the total fixed capital amounting to about Rs. 30 lakh. The cost of conversion of one kilogram of virgin zinc metal into one kilogram of zinc dust in a plant of such a capacity has been estimated at 90 paise.

The zinc dust produced by NML know-how generally conforms to the following specifications required for use by the hydrosulphite industry:

Sieve analysis :

75 μ, 98% max.; 45 μ, 90% min.

Chemical analysis :

Metallic zinc, 94% min.; total zinc, 98%; metallic lead, 0.15-1%; Cu, 0.01% max.; As, 0.001% max.; Cl, 0.05-0.15%; Cd 0.01-0.2%; and Fe, 0.02-0.2%.

The use of zinc dust is primarily in the sodium hydrosulphite industry whose immediate demand is between 5000 and 6000 tonnes per annum. Other users are the pigments industry and the rayon industry who are likely to require upto 500 tonnes each annually.

Several captive units can be set up by zinc smelters to meet the current demand. These units may each be rated at 3000 tonnes per year. Smaller units of 1500 tonnes per annum capacity will also be economically viable in the small scale industries sector.

The conversion of zinc metal into extra-fine zinc dust involves melting, and vaporization of the metal, and finally condensation of the zinc vapour using suitable media to yield dust of desired metallic content and sieve analysis. A totally controlled atmosphere is to be maintained. Appropriate dust collection systems have to be provided to entrain the fines as a measure of pollution control and for maximizing yield.

Extra-fine zinc dust may be prepared from pure zinc metal, spelter, or from wastes such as galvanizer's dross (hard zinc), and zinc die-casting scrap.

The main items of equipment include melting unit, vaporizing furnace, suitable condensation unit and dust collection system. Ancillaries include handling equipment, blending and weighing units and storage and packing systems. Instrumentation and controls covering temperature, flow and pressure are necessary. Sieving and sieve analysis, along with proper quality control equipment, are also required.

Two alternative locations for zinc dust production are possible. The most advantageous would be captive units located at primary zinc metal producing plants. This would obviate all problems of supplies of raw materials and also ease the problem of the availability of utilities.

The other alternative would be small scale industrial estates. Units so located would have to obtain their zinc metal supplies from appropriate sources. Or else, such units can draw upon the available supplies of metallic wastes such as galvanizer's dross or zinc die-casting scrap, the sources for which may be located nearby. Power and other utility requirements are quite modest.

The total capital outlay for setting up a plant capable of producing 3000 tonnes of chemical grade zinc dust per annum has been estimated at Rs. 29.75 lakh. The cost of conversion per tonne of dust comes to Rs. 900.

BOOK REVIEWS

SCIENCE YEAR, THE WORLD BOOK SCIENCE ANNUAL, 9th Edition 1974, Arthur G. Tressler, Ed. *Field Enterprises Educational Corp.*, Chicago, Illinois 60654, Pp 434, $ 6.95.

THE 1974 Year Book contains an assorted array of material on science, technology, medicine and parapsychology—sufficient to interest and instruct the most ignorant student, the most knowledgeable scholar and the most inquisitive layman. This Year's edition will be distributed to nearly half a million homes, schools and libraries in North America, in addition to other countries.

Space science, zoology and botany dominate the presentation. Seven visits to the moon in three and a half years have brought a fund of information to the field of lunar science and expanded our vision of the solar system. With captivating colour photos the Year Book aptly begins with this theme and briefly runs across the various Apollo missions which have now come to an end. The energy crisis is presented from the point of view of two new sources—the energy from the sun and the heat from the earth. While the harnessing of solar energy is a well established fact, the availability of heat from the rocks below is in an experimental stage. By pumping cold water down a 8000 m well into a hot dry rock area, engineers expect to release steam by a process of natural convection. The information obtained from NASA's rotating satellite *Uhuru* on the events in the universe, and Prof. Fowler's hypothesis of the missing neutrinos which may throw new light on the Sun's interior are presented here. *Uhuru* has discovered 125 new x-ray sources during the first 70 days of its space odyssey. Nearly two-thirds of these lie within 20 degrees of the galactic plane, while some sources found at higher latitudes have been identified with known extragalactic objects.

Reports in the bio-zoological sciences take the reader into the mysteries of chimpanzee life, their intellectual capacity to learn and their sign language; describe movement of bees, and explains how a genetic experiment to improve honey production in the western hemisphere has resulted in evil tempered honeybees spreading throughout South America and now advancing towards the United States. There is an interesting piece on the manner is which dogs should be treated. Man is *not* dog's best friend, because he has made the dog in his own image by projecting his needs of freedom, virility, and strength and at the same time expecting it to support his needs without really understanding the true difference between himself and the dog. A special audio-feature is Dr. Michael W. Fox's narration on 2 stereo records of the music-like sounds that are produced by canids like dogs, foxes, wolves and other hybrids. No lover of animals should miss reading these records.

The inhabitants of the valley of Vilcabamba in Ecuador, are known to have the longest span of life anywhere ranging from 100 to 150 years. Their longevity is traced to a low-calorie diet of around 1700 calories per day which is barely half of that consumed by residents of U.K. or USA. These findings have given an additional fillip to the study of the science of gerontology and led Prof. Bernard Strehler of the University of Southern California to discuss current trends in research in extending our life span. Linked with longevity is the elimination of disease which immunologist Jacques Chiller discusses in a report on new insights into immunity against cancer and other diseases. On the technological side the rush hour in city traffic which can be coped with a personal rapid transit system is described by an American professor; the rise of lasers in the coming decade outlined; advanced methods of rain-making through a knowledge of meteorology explained; and a description given of the gigantic Australian Snowy Mountains Scheme, which has rerouted rivers to produce electrical power and bring new fertility to the land. A graduate geology student presents a story of how archaeologists are using the varied tools of modern science to reconstruct everyday life in Bronze Age Greece.

A general report on scientific cooperation between USSR and the USA throws interesting light on the conditions of research behind the Iron Curtain, while another piece discusses the role of women scientists and sex prejudes that are prevalent in the USA.

The usual Science file is an assorted and alphabetically arranged digress on 44 science topics ranging from weed control by radio waves, discovery of deuterium in Jupiter's atmosphere and new light on quasars, to the use of fly ash in concrete products, progress in geosciences, elementary particle chemistry and diving gorillas. Those who have explored the frontiers of science and have achieved a measure of distinction receive recognition here. Works of Prof. R.R. Wilson, director of the sprawling $ 200 million National Accelerator Lab. at Illinois who guides the giant particle accelerator that forges the tiniest of subnuclear particles, and Jonas Salk who evolved the anti-polio vaccine and created his own Salk Institute for Biological Studies at La Jolla, California, have been highlighted through a detailed write-up with interesting side-lights on their own personal lives. Others, who have been the recipients of Nobel Prizes and other distinctions in scientific fraternity, are also duly given a share of brief biodata.

Perhaps the most unusual and the most interesting report and the first ever to be presented in this Year Book is the one prepared by Elmer and Alyce Green of the Menninger Foundation. They describe the framework of a new research frontier combining physics, parapsychology and medicine to grapple with the problems of the 'subconscious' which are to-day unanswerable by science. They describe the experiments carried out on India's Swami Rama, now living in Illinois, in which he rotated a 14 inch aluminium needle just by gazing at it, and how he created a temperature difference of 10°F between the thumbside and the little-finger side of his palm. As the Editor notes in his Preface, Greens' work is a part of a growing trend to take a serious scientific look at the unexplained but persistent phenomenon associated with Eastern philosophy that has little or no scientific basis from the point of view of Western culture.

Taken together, all the 17 reports and other material in the Yearbook provide an excellent selection of the ferment and diversity of topics,that characterise contemporary science and technology.

S.K. Ghaswala

BANGLAR PAKHI (Vol. 1) by Ajoy Home, *Priti Prakashani*, Calcutta, Pp. 228, Rs. 12.50.

MANY people still look down on birdwatching as merely a childish way of killing time indulged in by the idle and devoid of any scientific value. It may be so if you are content with merely watching a bird without any desire to identify it or know about its habits. But a systematic study of these colourful and often noisy creatures can not only be a source of immense delight but can also provide a life-long hobby which can be practised under almost any conditions.

Of course, to study birds you must first be able to recognise them. For this, a well-written (and preferably illustrated) guidebook of some sort can be of great help. The present volume is intended to provide such guidance to birdwatchers in Bengal. The author has selected more than 180 common birds of the plains of West Bengal and Bangladesh, but what is surprising is that they all belong to the single order of Passeriformes. It is not clear why some of the more common members of other orders have been left out. They include such common birds as the cuckoo, parrots, owls, kites, eagles, to name a few. There is also no mention of any of the numerous water birds that abound the river banks, jheels and paddy fields of Bengal. May be further volumes of the book will include them, but the author has nowhere mentioned it. (Incidentally, the standard practice in such works is to follow the evolutionary order in which the Passeriformes comes the last.) The get-up of the book is attractive, the illustrations are in black and white.

Biman Basu

ELEMENTARY CIRCUIT PROPERTIES OF TRANSISTORS by C.L. Searle, A.R. Boothroyd, E.J. Anjelo, Jr., P.E. Gray and D.D. Pederson, *Wiley Eastern Private Ltd.*, reprinted, 1973, Pp. 306, Rs. 12/-.

A few years after the invention of transistor in 1948 by William Shockley, a leading science journal brought out a special issue on transistors in which Shockley himself, made an important contribution (Transistor Electronics: Imperfections, Unipolar and Analog Transistors—*Proceedings of the Institution of Radio Engineers*, Volume 40, p. 1289, Nov., 1952). Development of semiconductor devices and transistor technology as well as publication of relevant literature followed, and by 1960 the progress in both the areas was considerable. Then microminiaturised electronic circuits appeared in the field which made it necessary to have clearer ideas about "circuits" and "devices". In America, at this time, a committee known as the Semiconductor Electronics Education Committee (SEEC), consisting of members from universities and industrial organisations, was formed to prepare a consolidated account of educational material in the form of books, films and laboratory experimental activities. The Committee brought out seven volumes; the last was published in 1966. The present book is the third in the series and was first published in the U.S.A. in 1964.

Since these books are intended for use by students at both senior and junior levels, the arrangements of topics included in each book and chapters in each of them, have been to impart thorough familiarity with the subject. In the present volume, the arrangement has been to deal with the elementary circuit properties of single-stage transistor circuits using models. Expected changes in values of parameters as a function of temperature, opera-

(*Continued on page 203*)

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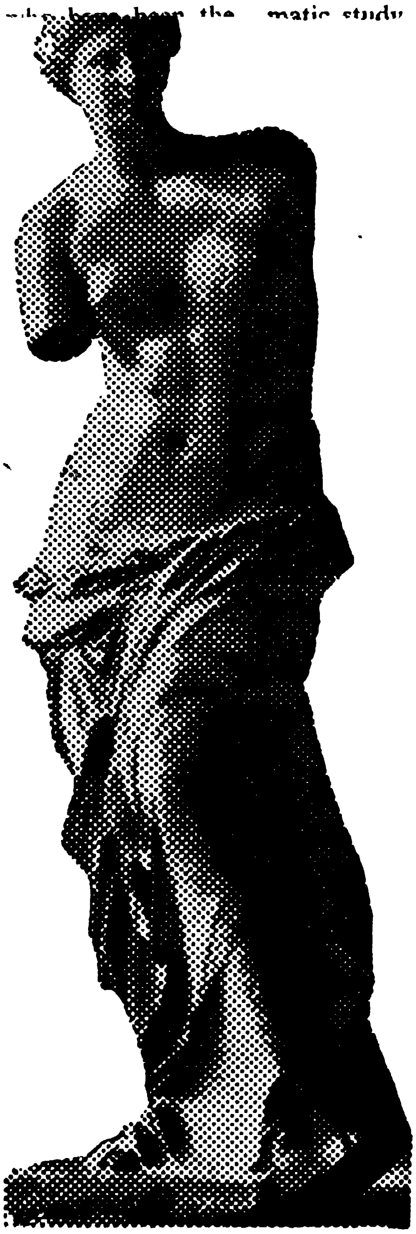

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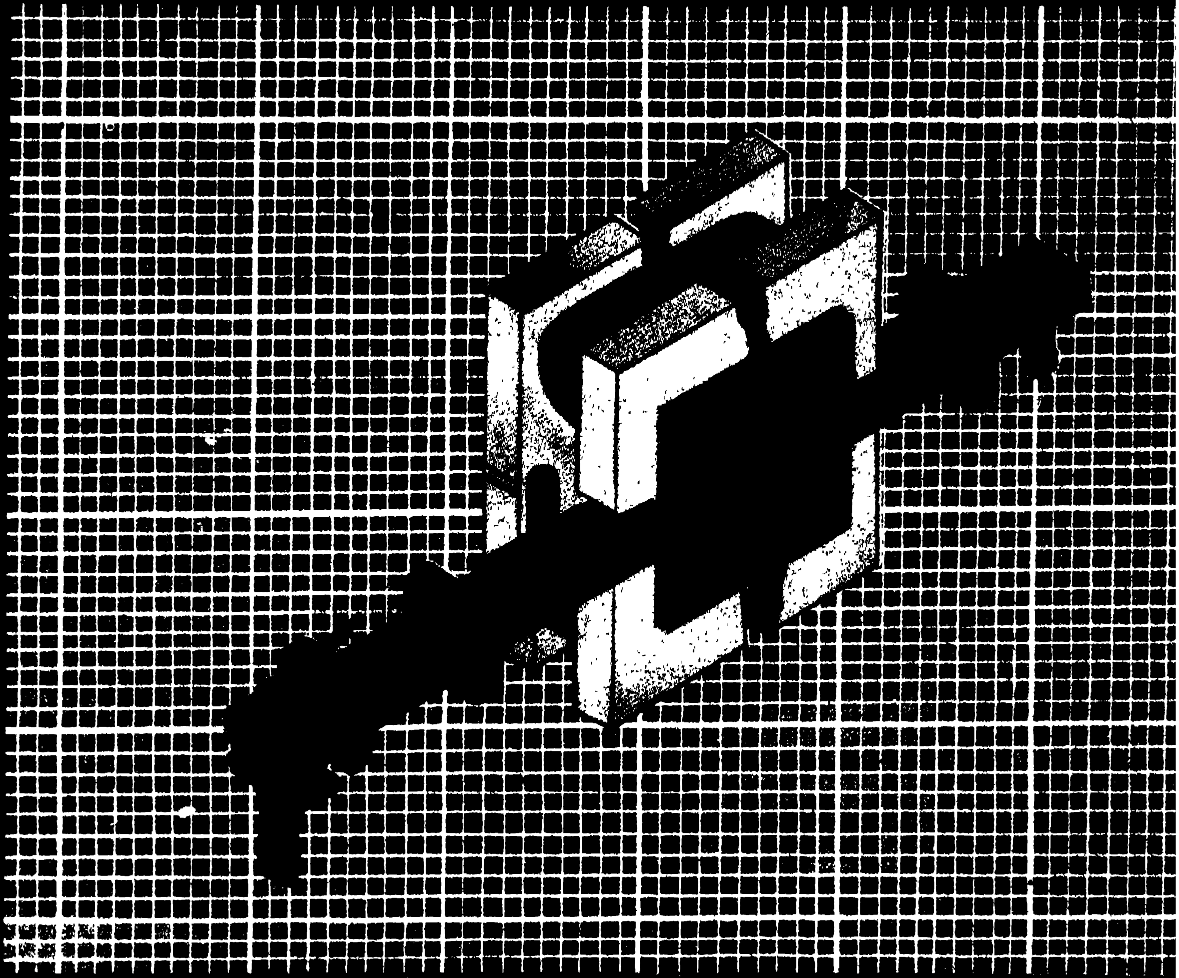

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LETTERS

S.N. Bose

Sir, I have read with interest and benefit G.H. Keswani's article "Satyendranath Bose—son of the soil", in March 1974 issue of *S.R.* In particular, the mathematical presentation of Planck's derivation by Bose is very thorough and clear.

I wish, however, to refer to certain statements and remarks in the article that are unwarranted—indeed jarring—in an otherwise esteemable account of the life, work and humanism of the great scientist.

The author of the article begins by saying that Bose's work "is the more remarkable being done without an adequate stimulation, except probably the company of his compeers, M.N. Saha and P.C. Mahalanobis." Shri Keswani evidently had in his mind the case of a research student working under a professor. But he himself has said next that a friend presented him Planck's *Thermodynamik* and *Warmestrahlung*. Well, this friend was none other than Prof. D.M. Bose, Ph. D. (Berlin), who had just returned from Germany after being interned there during the First World War. The stimulus, looked for by Shri Keswani, came from the study of the books.

Referring to the opinion pronounced by the mathematics teacher of the Hindu School, Calcutta, viz., that Satyen would come out one day as a great mathematician like Laplace and Cauchy, Shri Keswani has remarked "it is doubtful if a school teacher in Calcutta had heard of Cauchy."

If I am not mistaken the reference to the incident was based on my article "My friend Satyen", (a compliment to me!). However, why the author doubted the fact is not clear. We came to learn of Cauchy during our honours B.Sc. course from Burnside and Panton's *Theory of Equations*, Part II, viz., that the name "Determinants" was given by Cauchy who also developed the subject and wrote the first treatise on it. The mathematics teacher who made the prophesy about Satyen was one Upen Bakshi, an M.A. in mathematics and a noted teacher of our time, and the prophesy was made by him while lecturing in *our* class. He was a scholar of mathematics and could have read about Cauchy from B & P's book or from Florian Cajori's *History of Mathematics*. Shri Keswani's assertion is therefore out of place.

Thirdly, speaking of Bose's 2-year stay in Europe, the writer has observed that the stay was "infecund" inasmuch as Bose did not "write a single paper in Europe." What if he did not? Is it the idea that a paper written in Europe would have enhanced the merit and value of Bose's paper on "Planck's Law and Light quanta hypothesis" which, in the words of Dirac, "provided a corner-stone for the new physics of fundamental particles and quantas". There was no need for such a paper, nor did Bose make a sojourn to Paris and Berlin in order to write out papers.

Quoting from Blanpied's article in *Amer. J. Phy.* (1972), the writer says, "Bose never got an opportunity to work with Einstein and Madame Curie dismissed him by saying that he should learn French for six months and then go back to her." Tracking on a second-or third-hand knowledge, Shri Keswani was led into a pit. As I was in Paris in 1924, lodged in the same "pension" as Bose, at 17 Rue du Sommerard, I speak with first-hand knowladge; Bose *was* received in Berlin by Einstein with most cordial and warm welcome and was introduced by him to celebrities like Planck, Pauli, Heisenberg, Sommerfeld and others, and was made a visiting member of the *Colloquium* where the physicists met and held discussions. Bose went to Berlin not for working with or under Einstein, but for talks, discussions and exchange of ideas for which he had ample opportunity for over a year.

It is most surprising and painful to note that Shri Keswani says, "It is most probable that Bose was treated with condescension if not with indifference." Such observations coming from the pen of Shri Keswani form a queer mixture of adoration and disgrace for the great scientist. Shri Keswani himself has recorded that when the post of the Head of the Dept. of Physics in Dacca fell vacant, while Bose was still in Berlin, his friends urged on him to get a testimonial from Einstein in order to apply for the post. "When approached Einstein said something to the effect 'What! Do they not know about your work?'" Shri Keswani evidently does not know what Einstein wrote in his testimonial: indeed he wrote "We (i.e., the scientists in Berlin) have been benefited by his presence."

Here is a first-hand evidence. Prof. Herman Mark of the Polytechnique Institute of New York (a German chemist, who lived in Berlin in the 'twenties) in his condolence letter to the family of Prof. Bose (dated 20-2-1974) says, "His (re: Bose's) scientific intuition was such that he even sparked the genius of Einstein. My dear wife Mimi and I are fortunate to witness several meetings of these great minds."

As regards his reception by Madame Curie, let me quote from Bose's own account in *Jnan-O-Bijnan* (Oct.-Nov. 1967 issue) in an article on the hundredth birthday anniversary of Madame Curie (the translation into English is mine). "I went to Paris first. It was my hope to pick up new things (latest developments) so that on my return to Dacca, I may lead my students along new lines of work. With his (Langevin's) introduction letter I sought Madame Curie at her laboratory. Obtaining her permission I stepped into her chamber and found an old lady dressed in black, whom I recognised from having seen her picture before. She welcomed me cordially, reading Langevin's letter that I presented to her. "It is impossible" she told me "to deny to you the request coming from the letter writer." I would certainly get full facility to work under her care, she assured me, but added that it would be better if I started 3 or 4 months later after having acquired conversational French without which it would be difficult to carry on with laboratory work. Madame Curie herself conversed with me in smooth perfect English. I got no chance to tell her that having been acquainted with French over ten years I could manage tolerably with French.

Obeying, however, her advice I went back and returned to her laboratory after about 4 to 5 months and had the luck of working in the Radium Institute of Paris." Surely, this is not being "dismissed" by Madame Curie. I myself happened to be in Paris at this time and bear my personal testimony to the respect with which Bose was received by Madame Curie.

Lastly, the author of the article has mentioned that he could hardly find a text book giving a satisfactory derivation of Planck's Law. M.N. Saha's *Text Book of Heat* gives Planck's own and others derivations of the "Law".

G. BHATTACHARYA
Calcutta

I thank Dr. Bhattacharya and feel gratified that he read the obituary of Bose with "interest and benefit", as he generously puts it. His comment sets right and at rest, doubts about some historical points particularly those touching Einstein and Curie's reception of Bose in Europe. I noted with much gratification, what I had only guessed, that Einstein had indeed written on Bose's behalf for the Professorship at Dacca. I must bow before the corrected and satisfying related accounts of Bhattacharya, who was, after all, a contemporary and friend of Bose, and a personal witness to some connected episodes. I leaned trustingly on Blanpied's account. But why didn't someone write to Blanpied? His account was published in the Sept. 1972 issue of *American Journal of Physics* while Bose was alive. I imagine, Blanpied would have been happy to have corrected his report.

I am left with the feeling that Bhattacharya would have liked the obituary to be only a syrupy account, unmixed with any "jarring" comment, whatever. I wanted to see my Bose, fully as he was—with his unmistakable dimple of 1924, a few elegant moles of 1950's, but also the warts of 12 unproductive years following 1924, when he must have been at the height of his intellectual powers. I think, Bhattacharya should have given me the right, as a historian of science, to inquire why during two years of *study leave* in Europe, followed by 10 long years at Dacca Universiy, Bose should have written, not one paper or book.

Again, may I comment on another historical point? Dr. Bhattacharya contends that Bose did not go to Berlin to work with or under Einstein. In the second letter that Bose wrote to Einstein (which was reproduced in the obituary), Bose said clearly,—contradicting Bhattacharya's contention—"I do not know whether it will be possible for me to work under you in Germany. I shall be glad however if you grant me the permission to work under you, for it will mean for me realization of a long-cherished hope."

Incidentally, "could hardly find" does not mean "could not find".

G.H. KESWANI

II

Sir, This refers to the obituary on Prof. S.N. Bose written by G.H. Keswani (*S.R.* March, 1974). One may question the authenticity of the fact that the mathematics teacher (Sri Upendra Lal Bakshi) of Satyen Bose predicted that "Satyen would one day be a great mathematician, like Laplace or Cauchy", but to say that "It is doubtful if a school teacher in Calcutta had heard of Cauchy" is nothing but bad taste. It is regretable to find this in Shri Keswani.

Madame Curie did not 'dismiss' Prof. Bose; rather, allowed him to work in her laboratory under her guidance when Prof. Bose convinced her that he knew sufficient French.

While paying high tributes to Bose, Shri Keswani does not seem to give much importance to Bose's works on Einstein's Unified Field Theory. This is Bose's major contribution to science after 1924. Prof. Bose not only solved the hurdles (of 64 differential equations) that obstructed its development for many years but also developed it in a different way. Einstein proposed to talk about this with Prof. Bose on the occasion of the 50th anniversary of the Theory of Relativity, but the death of Einstein intervened. The Theory is still a live problem. It is therefore amazing how the question of the acceptance of a theory which is still not complete could arise as Shri Keswani observes that 'this theory itself has not found acceptance'.

Shri Keswani's observation of Prof. Bose as a 'staunch nationalist' is not quite clear. Bose was a nationalist—not in the sense that everything of his country was dear or acceptable to him.

His another observation that, "Bose did not take part in the Swadeshi Movement" is quite wrong. Prof. Bose did not escape the watchful eyes of the foreing rulers for his close association with freedom fighters of Bengal.

JUGAL KANTI RAY
Kasi Bose Lane
Calcutta

III

Sir, In the very good article "Satyendranath Bose—son of the soil" (*S.R.* March, 1974), the author says that 'Reading of original papers of the masters must be made compulsory for all advanced students.' I would request you to see if you could somehow arrange the publication in your magazine of Bose's original 1924 paper on the derivation of Planck's Law. It would greatly help your readers as Bose was truly a great master.

ATUL K. GUPTA
Christian Ganj
Ajmer

IV

Sir, I thank you and G.H. Keswani for contributing an obituary article "S.N. Bose—son of the soil" (*S.R.* March, 1974). It was an interesting article for science students and even for laymen. Articles on Indian scientists and their contributions in the field will be of great use to the readers of *S.R.*

CHITRALEKHA JAIN
Laxmi Nagar
Delhi

V

Sir, The view expressed by Shri G.H. Keswani, (*S.R.* March, 1974) in the "Life" section of the article "Satyendranath Bose—son of the soil" is rather objectionable. We are surprised to see that he has tried to make reflection on the quality of the teacher in a leading school in Calcutta in those days. How can he have an occasion to doubt that a teacher of mathematics at that time in a leading school had hardly heard the name of a great scientist like Cauchy when any serious student of mathematics could perhaps easily say who he was.

Placed in a responsible position, Shri Keswani should have refrained from expressing such uncharitable views about the knowledge of teachers in a leading metropolitan city in India.

NITINDRANARAYAN CHAUDHURI
Dept. of Geology
Presidency College
Calcutta

Betel

Sir, 'They go with betel' (*S.R.* November, 1973) was interesting, instructive and based on scientific facts.

However, the original *Tambool* did not contain tobacco, peppermint or slaked lime (instead *shouktika*, organic calcium, was used). They are stimulants and irritate the mucus membrane of the mouth and intestines. Constant irritation of mucus membrane is a cause of cancer. Hence, if lime, tobacco and peppermint are omitted, 'pan' with other ingredients in a limited quantity is quite harmless and may promote other medicinal properties.

DR. P.V. JAYADE
Koppikar Road, Hubli (Karnatak)

Proteoid roots

Sir, Re, "Proteoid roots" (*S.R.* September, 1973), I want to know the difference between the parent root and 'axis' clearly.

MAHENDRA K. CHATURVEDI
Jhansi (U.P.)

The portion of parent root bearing the dense clusters of rootlets is termed axis, while the portion devoid of dense clusters of rootlet is termed parent root.

II

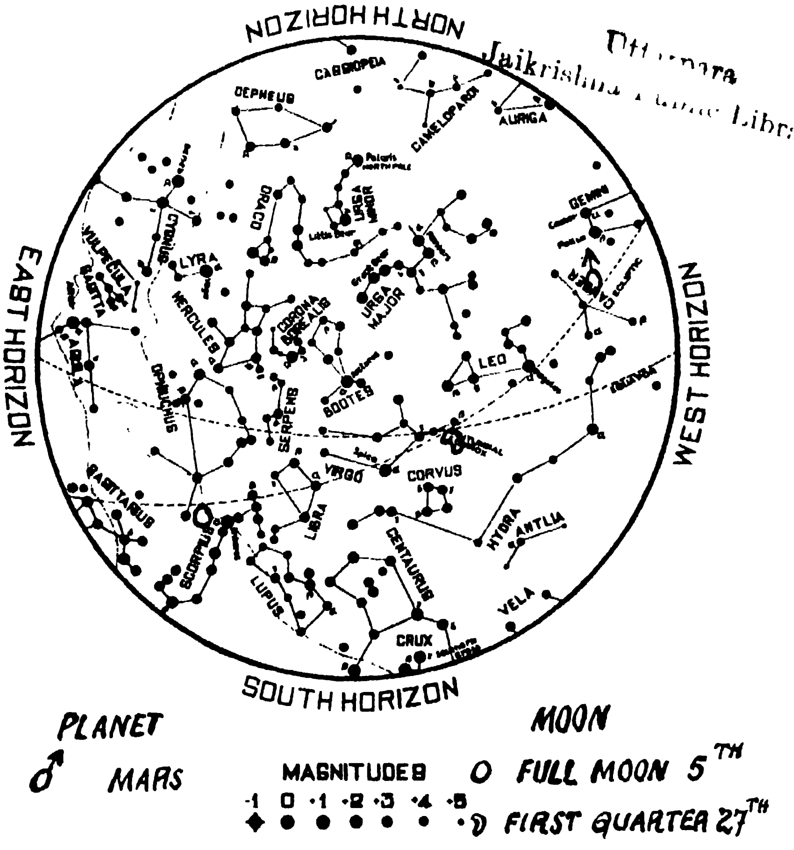
Sir, Thanks to V.K. Sharma and O.S. Singh for their informative article on Mitochondrial DNA (*S.R.* October, 1973). I have two problems: 1. It is evident that *m*-RNA is synthesized from DNA and both *r*-RNA aud *t*-RNA are synthesized from *m*-RNA. What affects the formation of *t*-RNA or *r*-RNA from *m*-RNA.

SUBHASH C. NIGAM
Bijnor (U.P.)

Synthesis of *t*-RNA and *r*-RNA is also dependent upon DNA. DNA acts as a template for the synthesis of different types of RNA which contain the specific inherited sequence of bases. The requirements for the synthesis of RNA on the DNA template are ATP, UTP, GTP, CTP, DNA and RNA-polymerase.

V.K. SHARMA
Dept. of Botany, Punjab
Agri. University, Ludhiana

PLANETS AND THEIR POSITIONS—JUNE 1974



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The moon

FULL moon occurs on 5th at 3-40 a.m. and New moon on 20th at 10-26 a.m. I.S.T. The moon passes about seven degrees north of Jupiter in the early hours of 13th, about four and a half degrees north of Venus on 17th, and about five and a half degrees south of Mars on 23rd, The lunar crescent becomes first visible after the new moon day in the evening of 21st. The moon is at apogee or farthest from the earth on 9th and at perigee or nearest to it on 21st.

The sun is at the summer solstice on the 22nd.

There will be a partial eclipse of the moon in the early hours of 5th. It is partly visible in India. The eclipse begins at 2-09 a.m. and ends at 5-23 a.m. I.S.T. There will also be a total eclipse of the sun on 20th, but it is not visible in India.

The planets

Mercury (Budha) sets about an hour after sunset during the first three quarters of the month. Thereafter it is too near the sun to be visible. It is at the greatest eastern elongation of about 24 degrees from the sun on 4th and becomes retrograde on 18th. It passes about two degrees north of Saturn on 2nd. It is in Gemini (*Mithuna*). Its visual magnitude varies from +0.4 to +2.1.

Venus (Sukra), a morning star, rises about two hours before sunrise during the month. It moves from Aries (*Mesha*) to Taurus (*Vrisha*). Its visual magnitude is about —3.4.

Mars (Mangala), visible in the evening sky, sets about three hours after sunset during the first half of the month and about two hours after it during the second half. It is in Cancer (*Karkata*). Its visual magnitude is about +2.0.

Jupiter (Brihaspati) rises at about local midnight during the first half being at quardrature with the sun on 7th. Thereafter it rises about an hour before local midnight. It is in Aquarius (*Kumbha*). Its visual magnitude is about —2.0.

Saturn (Sani) sets about an hour after sunset during the first half of the month, after which it is too near the sun to be visible being in conjunction with the sun on 30th. It is in Gemini (*Mithuna*). Its visual magnitude is about +0.3.

(*Source*: Nautical Almanac Unit of the Meteorological Office, Alipore, Calcutta-27).

MICROWAVE SPECTROSCOPY

K. P. RAJAPPAN NAIR

The development of microwave spectroscopy, based on rotational and inversion motions of molecules, is a striking example of the pure and applied sciences progressing hand in hand

FRONTIERS of spectroscopy have been extended to the microwave region of the electromagnetic spectrum by the development of devices and techniques during World War II for generating and detecting short wave radiations. History of scientific research always shows a regular pattern. Generally the basic ideas are first put forward and tested in basic research laboratories and then used by the applied scientists for a wide variety of different purposes. The unique exception is the origin and development of microwave spectroscopy during the last twenty-five years. Fundamental research in this field is now tremendously increasing, yet none of this work would have been possible at all without the great efforts of applied scientists in developing short wave radiations during World War II. The concentrated research on microwave radar provided the necessary instruments and impetus for the rapid development of the field, even though microwave spectroscopy had its inception in 1934 with the historic experiments on the inversion spectrum of ammonia.

Since its advent, microwave spectroscopy has established itself as a powerful tool for studying a variety of fundamental molecular properties. Although best known for its ability to provide precise values of bond lengths and bond angles, microwave spectroscopy has also been one of the best means to obtain other molecular parameters such as dipole moments, nuclear quadruple coupling constants, nuclear masses, molecular magnetic moments, low lying vibrational levels, barrier to internal rotation, conformation and energy differences in rotational isomers. New applications are continuously being developed, and, of course, there is no end in sight. Till now it almost remained in the hands of specialists in this field. This is due to the fact that the instrumentation is rather more complex than for many other fields. However, the trend is now changing with the availability of commercial instruments since 1968.

The electromagnetic spectrum

The electromagnetic spectrum extends from the high energy γ-rays at one end to the long wavelength radio waves at the other (Fig. 1). The characteristic feature which distinguishes one region of the spectrum from the other is its wavelength. One of the beautiful ideas put forward by

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Dr. Nair is working in the department of chemistry, University of Texas, Austin, Texas, U. S. A.

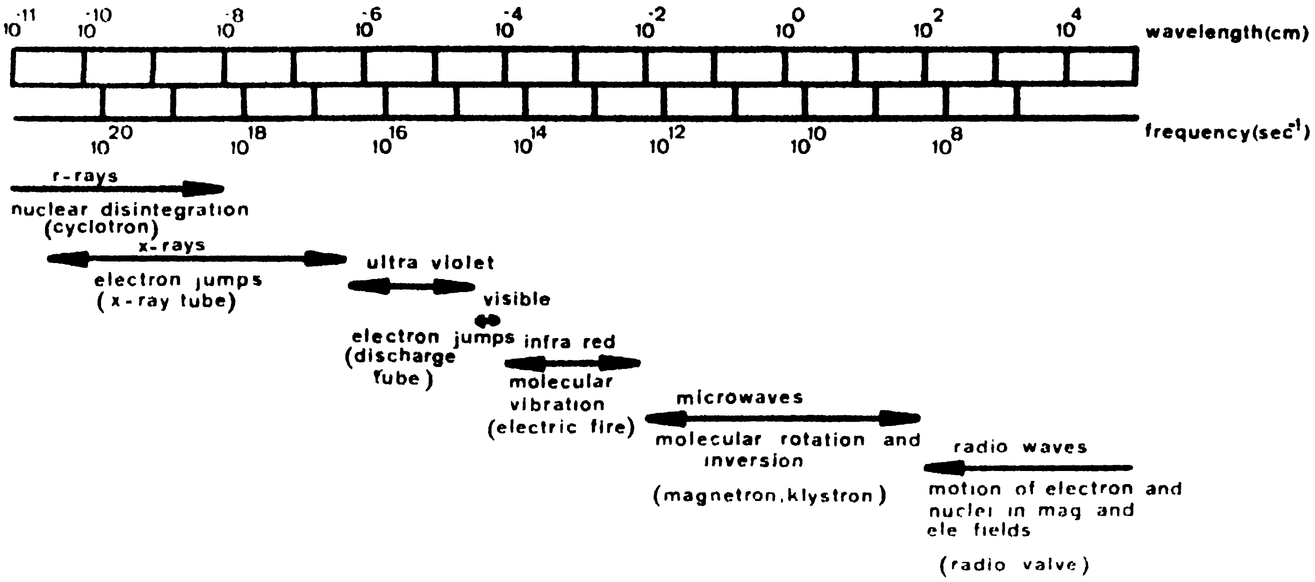

Fig. 1. The electromagnetic spectrum

Niels Bohr at the beginning of this century, on which the whole of modern physics is built, is that each wavelength is associated with a quantum of energy $h\nu$, where ν is the frequency of radiation. Atom consists of a central nucleus and a number of electrons circling round it in different orbits. Radiation in the visible region is produced by electron jumps among the outer orbitals of the atom. The difference in energy between the orbits in which a transition has occurred corresponds to a frequency (or wavelength) in the visible region. The radiation in the ultraviolet region is similarly produced with the exception that the jumps are now somewhat larger. When there are much larger jumps of electrons from an outer orbit to a vacant inner orbit of a heavy atom, much larger energy quantum is emitted and x-rays are produced. The radiations of high energy, termed γ-rays, originate not from any change in the electron orbits but from some disturbances in the nucleus. It is by the detailed study of these radiations that one gets information about the electron configuration and also the interaction taking place in the nucleus itself.

Coming to the other end of the electromagnetic spectrum, the infrared radiation is produced by molecular vibrations. A molecule is a collection of two or more atoms and the atoms in a molecule are not perfectly at rest. They are always vibrating and rotating and the radiations associated with these motions lie in the infrared and microwave regions. Hence, the study of the spectra in these regions gives informations about the molecular forces which bind atoms together. The very high resolution available in the microwave region, however, allows a great variety of extra information to be obtained. To complete the survey, the radio frequency region is associated with the motion of electrons and atomic nuclei in externally applied electric or magnetic fields.

Microwave spectra

The microwave region is the part of the electromagnetic spectrum with wavelengths ranging from about one tenth of a millimeter to 100 cm. Hence microwave spectroscopy is sometimes regarded as an extension of radiofrequency spectroscopy or as an extension of infrared spectroscopy. There are nevertheless ample reasons to treat it as an independent subject. The instruments for generating, transmitting and detecting microwave radiations are entirely different from those for radio-frequency regions. They are also fundamentally different from the optical instruments used in conventional spectroscopy. Hence microwave spectroscopy can conveniently find a place either in an electronic laboratory or in a spectroscopy laboratory.

The microwave spectra of most molecules correspond to changes in the rotational or inversion motions with various fine structure effects superimposed. As mentioned earlier, the first experiments on microwave spectroscopy was conducted on the inversion frequency of ammonia molecule. The structure of ammonia molecule is a simple pyramid with a nitrogen atom symmetrically placed above the plane of the three hydrogens (Fig. 2). It is possible for the single nitrogen atom to occupy any side of the hydrogen plane. In fact at normal temperatures the nitrogen atom vibrates rapidly between these two stable configurations giving rise to a frequency of about 24,000 MHz or a wavelength of 1.25 cm. This is called the inversion frequency of ammonia.

Rotational spectra

As has been discussed earlier, the energy quanta in the microwave region corresponds to rotation or inversion of the molecule. Depending upon the structure and symmetry, the molecules are generally divided into three categories in microwave spectroscopy, viz., linear molecules, symmetric top molecules and asymmetric top molecules.

Linear molecules. If we consider the molecule as a rigid rotor (which is not really true for a real molecule because of the presence of other interactions like vibration, inversion, etc.), the rotational energy levels of a linear molecule has a simple form as

$$E(J) = \frac{h^2}{8\pi^2 I} J(J+1) \qquad ..(1)$$

where J is the rotational quantum number which can take integer values 0,1,2,..., I is the moment of inertia of the molecule and h is the Planck's constant. The expression is generally written in a still simpler form as

$$E(J) = hBJ(J+1) \qquad ..(2)$$

where $B = h/8\pi^2 I$, called the rotational constant of the molecule. The transitions between energy levels take place following certain quantum conditions called selection rules. By combining the selection rule $\Delta J = \pm 1$, which means that a frequency is absorbed or emitted when a molecule changes its position from the quantum state J to $J+1$ or $J-1$. For absorption where $J \rightarrow J+1$, the rotational energy change is:

$$\Delta E = 2hB(J+1) \qquad ..(3)$$

which corresponds to an absorption frequency

$$\nu = 2B(J+1) \qquad ..(4)$$

This is a simple expression which describes the rotational spectra of a linear molecule. Small deviations from it are attributable to the non-rigidity (i.e., the interaction of vibration on rotation) of the molecule. It is clear from the above expression that by a study of the rotational spectra one obtains the moment of inertia of a molecule through the rotational constant and hence the internuclear distance.

Symmetric top molecules. In the case of a linear molecule the molecular parameters which determine the rotational energies of a rigid rotor are the moments of inertia. This is true for other types of molecules also, the only difference is that there are three moments of inertia associated with a non-linear molecule. These depend on the masses of the nuclei and their coordinates. Corresponding to the three moments of inertia I_a, I_b and I_c, there are three rotational constants designated as A, B and C. By convention, the rotational constants are identified with the principal axes in such a way that $A > B > C$, i.e., $I_a < I_b < I_c$ and are normally given in MHz. When two of the rotational constants in a molecule are equal then it is termed as a symmetric top molecule. It is called a prolate symmetric top if $A > B = C$ and oblate symmetric top if $A = B > C$. Energy levels of such a rigid rotor are given by

$$E(J,K) = h[BJ(J+1) + (A-B)K^2] \qquad ..(5)$$

where $B = \frac{h}{8\pi^2 I_b}$ and $A = \frac{h}{8\pi^2 I_a}$.

Here J and K are quantum numbers.

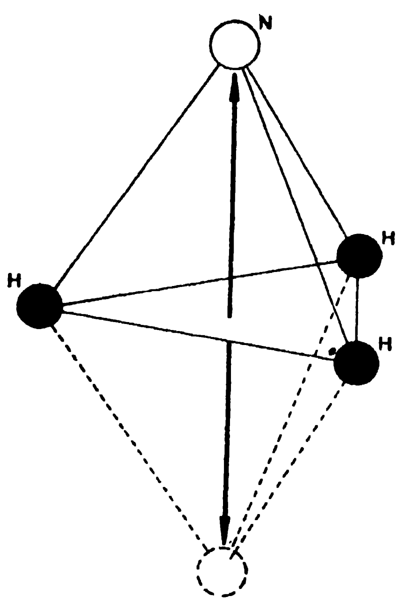

Fig. 2. The ammonia molecule

Transitions between the energy levels take place following certain selection rules and by studying the spectra one obtains the values of the rotational constants which corresponds to the moments of inertia of the molecule.

Asymmetric top molecules. There is a large class of molecules for which the three moments of inertia are not equal, i.e., $I_a \neq I_b \neq I_c$. Such a molecule is called an asymmetric top molecule. It is not possible to obtain a general solution for the energy levels of an asymmetric rotor in a closed algebraic form. However, the energy can be expressed as a function of a reduced energy $E(K)$ which is in turn function of an asymmetry parameter of the molecule. There is still another group of molecules for which $A = B = C$, called the spherical tops, which are of no importance for the microwave spectroscopist,

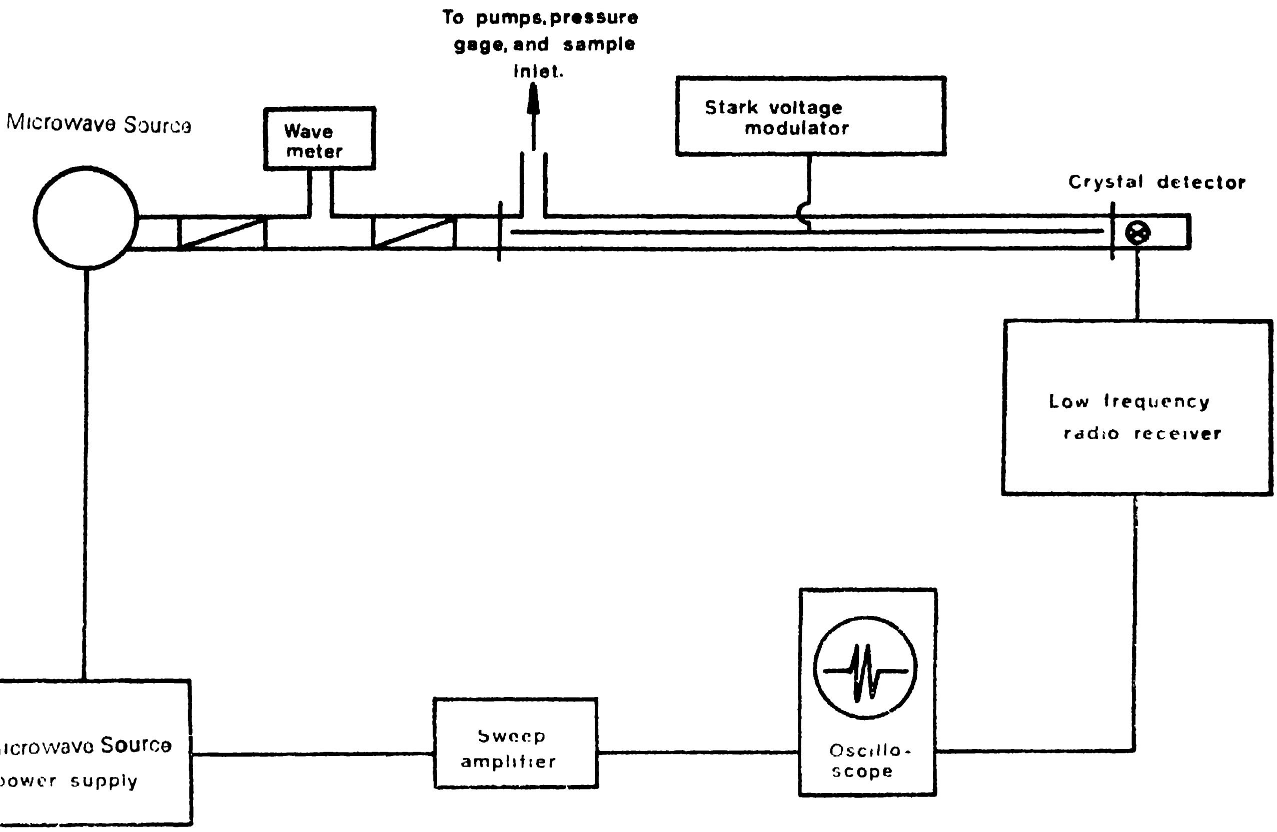
To pumps, pressure gage, and sample inlet.
Microwave Source
Wave meter
Stark voltage modulator
Crystal detector
Low frequency radio receiver
Microwave Source power supply
Sweep amplifier
Oscillo-scope

Fig. 3. Schematic set-up for microwave spectrometry

due to lack of molecular dipole moment in this class of molecules.

Microwave spectrometers

The most important development in microwave spectroscopy in recent years is the introduction of commercial spectrometers. Even though the aim of this article is not to give a detailed description of the complicated instrumentation, it will not be out of place to give the essential features of a microwave spectrometer. The most important part of a spectrometer working at any wavelength is the dispersing element. A spectrometer without a prism or grating is quite unimaginable in conventional spectroscopy. It is interesting to note that the spectrometer in the microwave region does not require any dispersive element such as a prism or grating. The source itself can be tuned so accurately that monochromatic radiation is produced. The other essential features of any spectrometer are: (1) the radiation source, (2) absorption cell, and (3) detectors. Among the radiation sources used in microwave spectroscopy the backward wave oscillators (BWO) have now largely superseded the earlier klystron source.

The most common technique for observing microwave spectra involves passing monochromatic microwave radiation through a waveguide cell filled with the sample gas. The amount of sample required is generally very small. The transmitted microwaves are detected by a diode crystal which produces a rectified d.c. signal. The sensitivity of the instrument can be increased by Stark modulation. The commonly used spectrographs in most of the microwave laboratories is a Stark modulation spectrograph. An intensity modulation of the microwave energy is obtained by applying a radio-frequency alternating voltage to the absorption cell. A block diagram of such a spectrograph is shown in Fig. 3. It is well-known that the microwave spectrometers in two laboratories are never the same (except the commercial ones now) in their techniques of production, measurement and detection of microwave frequencies. The outstanding features of the microwave technique from the experimental point of view are the ease with which frequencies can be measured very accurately and the high resolving power obtainable in this region.

Applications

Determination of molecular structure. One of the foundations of modern chemistry is the molecular structure and the foremost application of microwave spectroscopy is to the determination of molecular structure very accurately.

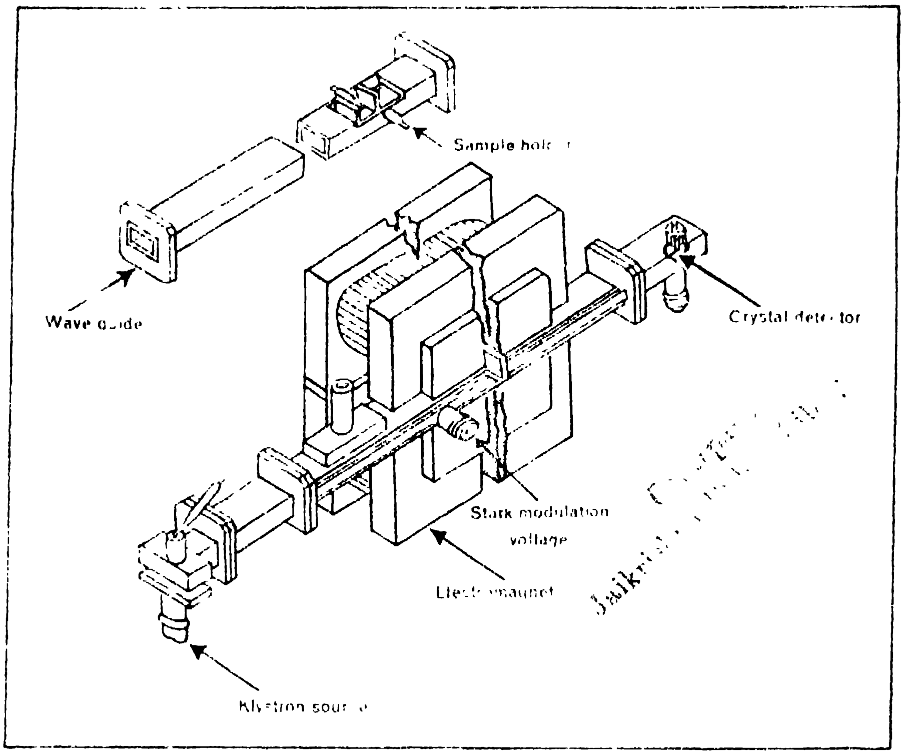

Fig. 4. Details of a wave guide used in microwave spectroscopy

Microwave spectroscopy has only one serious rival--the electron diffraction method-- for determining the molecular structure. Even though both methods have merits and demerits, the structure determined by the microwave spectroscopy technique is supposed to be more reliable. (The electron diffraction method has only one advantage over microwave spectroscopy in that it can be used for studying the structure of completely non-polar molecules also, which is not possible by microwave spectroscopy.) It is true that the analysis of complicated microwave spectra can lead to wrong assignment of individual rotational lines and hence wrong rotational constants and molecular structure. However, there are a large number of checks in assigning the quantum numbers to various transitions and hence a microwave spectroscopist can always claim that his results are more reliable. Once the assignment of lines is completed, various quantum mechanical formulas are applied in order to get the rotational constants, moments of intertia and other molecular parameters.

Dipole moment. Dipole moments have historical importance in chemistry partly due to the fact that the existence of a non-vanishing moment shows that certain symmetry elements are absent in the molecule. Basically, the molecular dipole moment is the total electronic charge multiplied by the distance between the centres of positive and negative charges in a molecule. Microwave spectroscopy has proved to be an excellent method of obtaining molecular dipole moments. The values are obtained by studying the Stark effect pattern after applying a uniform electric field to the gas. The presence of an external electric field induces a torque on the rotating molecule which slightly alters its energy levels. The change in rotational energy depends on the orientation of rotational motion with respect to the field, and is larger for molecules with larger dipole moments. Thus each rotational energy level splits in the presence of a field and the shift in frequency of each component can be related to the dipole moment. The usual accuracy of this method is about 1 to 2 per cent, sometimes even less. Microwave spectroscopy technique can measure quite small values of dipole moments; however, it is very difficult to prove by any known method that the dipole moment is strictly zero.

Internal rotation. The most important field to which the microwave spectroscopists' attention turned recently is the internal rotation of molecules. Internal rotation is a term used to describe the rotation of one part of the molecule with respect to the other. There is always a small potential energy interfering in this rotation which is called 'barrier to internal rotation'. Microwave spectroscopy provides the most powerful method at present for studying this phenomenon, and since the associated quantum mechanics are relatively complicated the method is mainly devoted to the study of a special class of internal rotation, namely, internal rotation of methyl groups in simple molecules. The pure rotational transitions are split into doublets in the presence of an internal rotation of a methyl group. Various quantum mechanical theories for this phenomenon have been developed now. A study of the splitting gives the magnitude of the potential barrier hindering internal rotation to an accuracy of less than 5 per cent. Barrier heights are now being determined for a large number of molecules by this method and this is a valuable aid to the theoretical chemist who is still waiting for accurately determined experimental values to prove his theories to explain the origin of barrier forces. The experimental achievements have not yet been matched by corresponding developments in understanding the electronic origin of barriers. A large number of well determined barriers for similar molecules might give an insight to their origin.

The other direct applications of microwave spectroscopy are in the determination of nuclear quadrupole coupling splittings caused by the presence of atoms like N, Cl Br, etc., having nuclear spins of unity or greater; determination of molecular conformations, centrifugal distortion and chemical bond and a number of other molecular phenomena.

Microwave spectroscopy and radio astronomy

The two fields in which physics has made the greatest stride since the War have been, first, in high energy nuclear physics and second, in the study of radio physics, both in the fields of radio astronomy and microwave spectroscopy. Spectroscopy has been a powerful tool for studying the physical and chemical nature of the Universe ever since the discovery of spectrum by Sir Isaac Newton in 1666. Besides leading to the detection of various molecules and atoms on stars, planets and comets, in the upper atmosphere and in interstellar space, detailed analyses of the spectra enable us to reach definite conclusions concerning the physical conditions in these bodies. It also helps in the accurate determination of distances between the stars and their velocities and yields a wealth of other information about the Universe. Although most of the work of radio astronomers has been concerned with the measurement of radio noise at different frequencies from interstellar space, there is a discrete spectral line of atomic hydrogen at a wavelength of 21 cm which has been discovered and used very widely by them. Even though the spectrum of atomic hydrogen is very simple and has been the tool of the well-known scientists like Rutherford, Thomson, Bohr and Schrödinger for proving the various theories of atomic structure, the origin of the 21 cm line escaped the notice of these people.

The atom of hydrogen consists of a central nucleus with a single electron rotating around it. Both the nucleus and electron have their own individual spins and magnetic moments. In a hydrogen atom either the two spins and magnetic moments are aligned in one direction (parallel) or they are in opposite directions (antiparallel). No other combination is possible according to quantum theory. These two states of the atom have slightly different energies and when one of the spins changes its direction the atomic hydrogen will move from one energy state to the other and either emit or absorb the quantum of energy giving rise to a spectral line which lies at a frequency of 1420 MHz corresponding to a wavelength of 21 cm. It, therefore, follows that when a radio astronomer picks up this signal from outer space it is evident that it originates from atomic hydrogen in which the proton and electron spins are reorienting. This can be used not only to identify the presence of hydrogen, but can be used in conjunction with Doppler effect to study the relative velocity of hydrogen cloud with respect to earth.

Among other important outcomes of researches in microwave spectroscopy are the Masers and Lasers, the uses of which are unlimited in applied science. The development of microwave spectroscopy is thus a striking example of the pure and applied science progressing hand in hand.

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CHEMICAL CLUES TO MENTAL DISORDERS

RAJ SHANKAR

Manifestations of behavioral states and emotions like anger, fear and love have been traced to particular concentrations of amines in healthy brains. Any abnormal change in their molecular set-up leads to grave mental disorders

IN the last few decades, considerable advances have been made in many fields of research. However, progress in the understanding of brain function has been much slower during this period. The main reason for this has been the lack of suitable experimental subjects for behavioral studies. One cannot study the feelings of fear, anxiety and love in experimental animals. Another reason has been the lack of suitable experimental methods and techniques for the microanalysis of chemicals in single nerve cells or a small group of cells. Several attempts to understand the functioning of brain in health and disease have been frustrating. Some pessimists have even come forward to say that the "brain cannot solve its own mystery", although others are more optimistic.

Before one can understand the biochemistry of mental disorders, one has to know how a normal brain functions. Due to the efforts of scientists, we now have some knowledge about the chemistry of the brain. Such studies point out that the majority of mental disorders have a biochemical basis. Changes in the metabolism of some important brain constituents have now been proved to result in behavioral states which are in many cases identical with diseased states.

The synapse

The basic functional unit of the brain is the nerve cell or neuron. Calculations show that an adult human brain contains 10^{23} neurons. But these are not the only type of cells present in this complex organ. There are also other types of cells known as glial cells, which have a nutritive and supporting function. Each neuron sends off a number of processes, the axons, which branch to small fibres, the dendrites. The region where the dendrite from one neuron is attached to that from the other is known is a synapse. Each nerve cell is attached to another or several nerve cells by such synapses (Fig. 1).

At resting state there is a steady difference of potential between the inside and outside of the neuron (the resting potential). Outside of the neuron is positively charged. This is due to unequal distribution of Na^+ and K^+ ions inside and outside of the cell.

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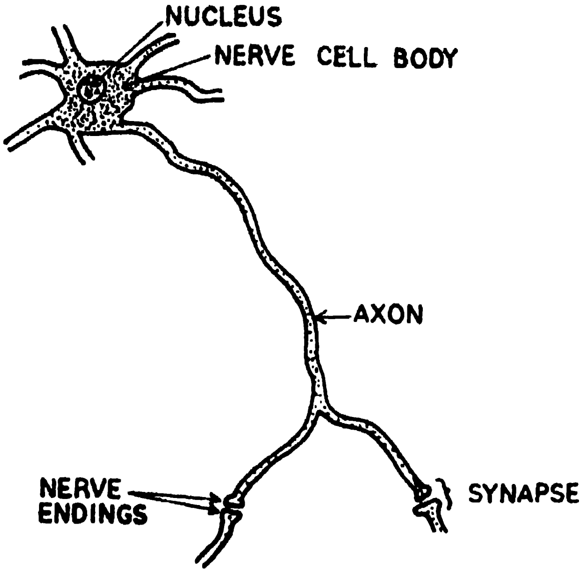

Fig. 1. Structure of a neuron

During transmission of a nerve impulse, the permeability of neuronal membrane to sodium ions changes causing depolarization at the membrane. This wave of excitation travels along the axon to its terminal end. Since there cannot be an electrical conduction of impulses between two nerve cells, chemical transmission occurs (Fig. 2).

Neurotransmitters

When the nerve impulse reaches the synapse, it releases certain chemicals called neurotransmitters from the nerve endings. In a resting nerve, these chemicals are present in a bound form, whereas during signal transmission they act at certain specific sites known as receptors. The action of neurotransmitters on the receptors results in changes in the permeability of the post-synaptic nerve membrane. Sodium crosses the membrane from outside. This causes development of an action potential which continues to proceed further along the axon and goes to another synapse.

The neurotransmitters, released from the nerve endings are later destroyed by specific enzymes. Several neurotransmitters are known today, the most important ones are acetyl choline, norepinephrine, dopamine and serotonin. It is now believed that in one nerve only one type of neurotransmitter is present. Acetyl choline is synthesised from acetyl CoA and choline and is destroyed at synaptic cleft by the enzyme acetyl choline-esterase (AchE). The monoamines norepinephrine (NE), serotonin (5-HT, 5-hydroxytryptamine) and dopamine are synthesised from the amino acids tyrosine and tryptophan and destroyed by two enzymes monoamine oxidase (MAO) and catechol-*o*-methyl transferase (COMT) (Fig. 3). It is now generally agreed, as we shall see later, that norepinephrine-containing neurons are involved in anxiety and depression, while serotonin-containing neurons are involved in sleep, appetite, sex and higher mental functions.

Cerebral amines and behaviour

The process of chemical transmission between two nerves may be affected by a number of drugs. Changes in chemical transmission are considered to be the primary defects in a number of mental disorders. Evidence in support of this has come from several different disciplines such as neurophysiology, neurobiochemistry, neuroanatomy and neuropharmacology.

The major advancement in this area took place in 1943 when a Swiss chemist Albert Hofmann took some LSD accidentally and experienced visual and beha-

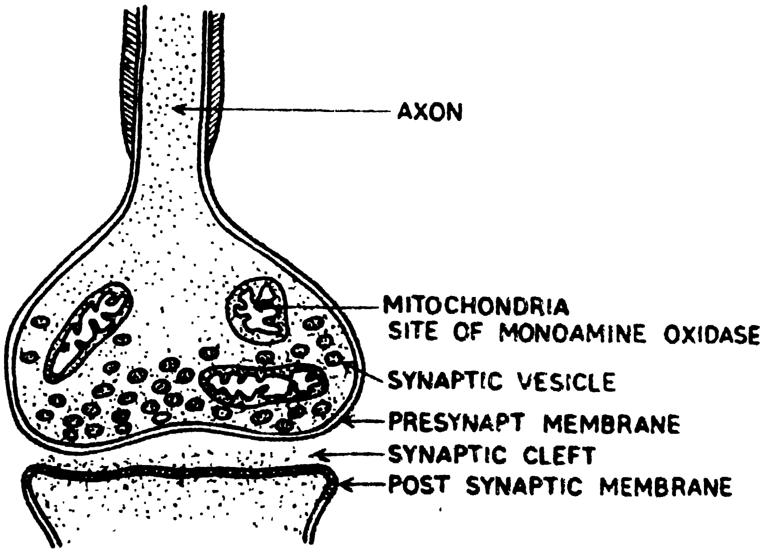

Fig. 2. Detailed structure of a synapse

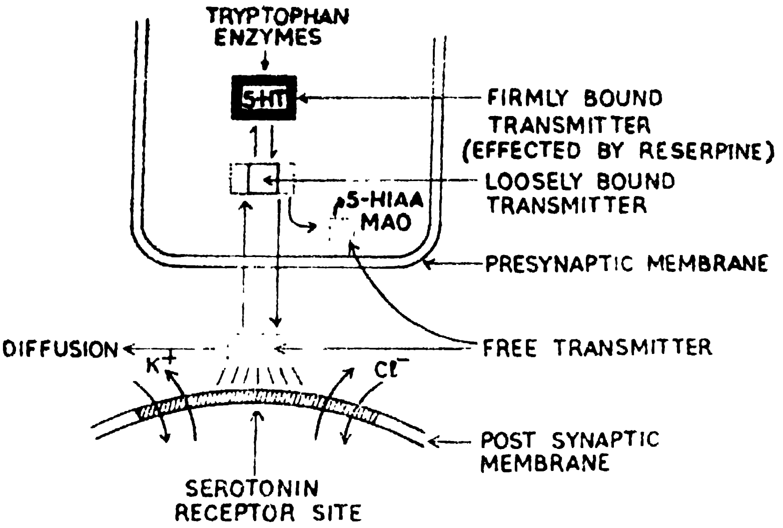

Fig. 3. Schematic diagram of a serotonin containing synapse

vioral changes. Later, after the discovery of serotonin in brain, it was found that LSD antagonises the effect of serotonin at the synapse. Investigators then concentrated their efforts to find out the relation between serotonin and behavioral disorders. Since some of the effects of LSD were similar to 'psychosis' or madness, it also raised the possibility that serotonin is involved in schizophrenia—the most common form of mental disorder.

In the early' fifties reserpine, a drug obtained from the plant *Rauwolfia serpentina,* was shown to cause sedation in animals. At the same time a decrease in serotonin and norepinephrine content of the brain was observed. It was also found that iproniazid, a drug used in the treatment of tuberculosis, relieves many patients from depression and causes alertness. Parallel to these behavioral effects, the monoamine level in the brain was found increased. These and other similar observations led to the belief that the monoamines were involved in emotional state and behaviour of animals.

Role of serotonin

Although a great deal of work has been carried out on serotonin, the exact role of this amine in relation to animal behavior is uncertain. It has been proposed that changes in the concentration of serotonin due to LSD or other similar compounds at the effective site (a group of synapses) may be related to changes in normal behaviour. Thus the behavioral effects due to psychogenic drugs may be due to change in the concentration of the free transmitter acting on post-synaptic receptor site.

P-chlorophenylalanine (PCPA) inhibits the activity of tryptophan hydroxylase, the enzyme which catalyses the first step in the biosynthesis of serotonin. This results in a fall in serotonin content without parallel changes in dopamine and norepinephrine contents. Animals given PCPA show marked decrease in sleep-time which is proportional to the fall in serotonin content. Other behavioral effects include development of excessive sexual activity and increased aggressive behavior. The effect can be reversed by administration of 5-hydroxytryptophan, which is a precursor of serotonin.

Biogenic amines and emotion

There is now sufficient evidence to show that acetylcholine and the catecholamines, dopamine and norepinephrine, may be related to the emotional state of the animals. When cholinomimetics (substances which can antagonise the action of acetylcholine at the receptor) are given to experimental animals, they develop aggressive killing behavior.

Physiological response in animals to anger closely resembles the one created by injecting norepinephrine alone, while that of the state of fear resembles the combined reaction of both norepinephrine and epinephrine. Similar relations have been established in a number of other

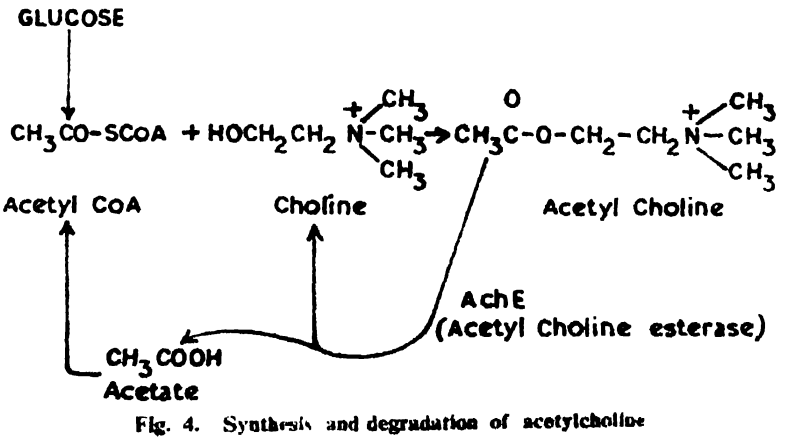
GLUCOSE
$CH_3CO\text{-}SCoA + HOCH_2CH_2\overset{+}{N}(CH_3)_3 \rightarrow CH_3\overset{O}{C}\text{-}O\text{-}CH_2\text{-}CH_2\overset{+}{N}(CH_3)_3$
Acetyl CoA
Choline
Acetyl Choline
AchE
(Acetyl Choline esterase)
CH_3COOH
Acetate

Fig. 4. Synthesis and degradation of acetylcholine

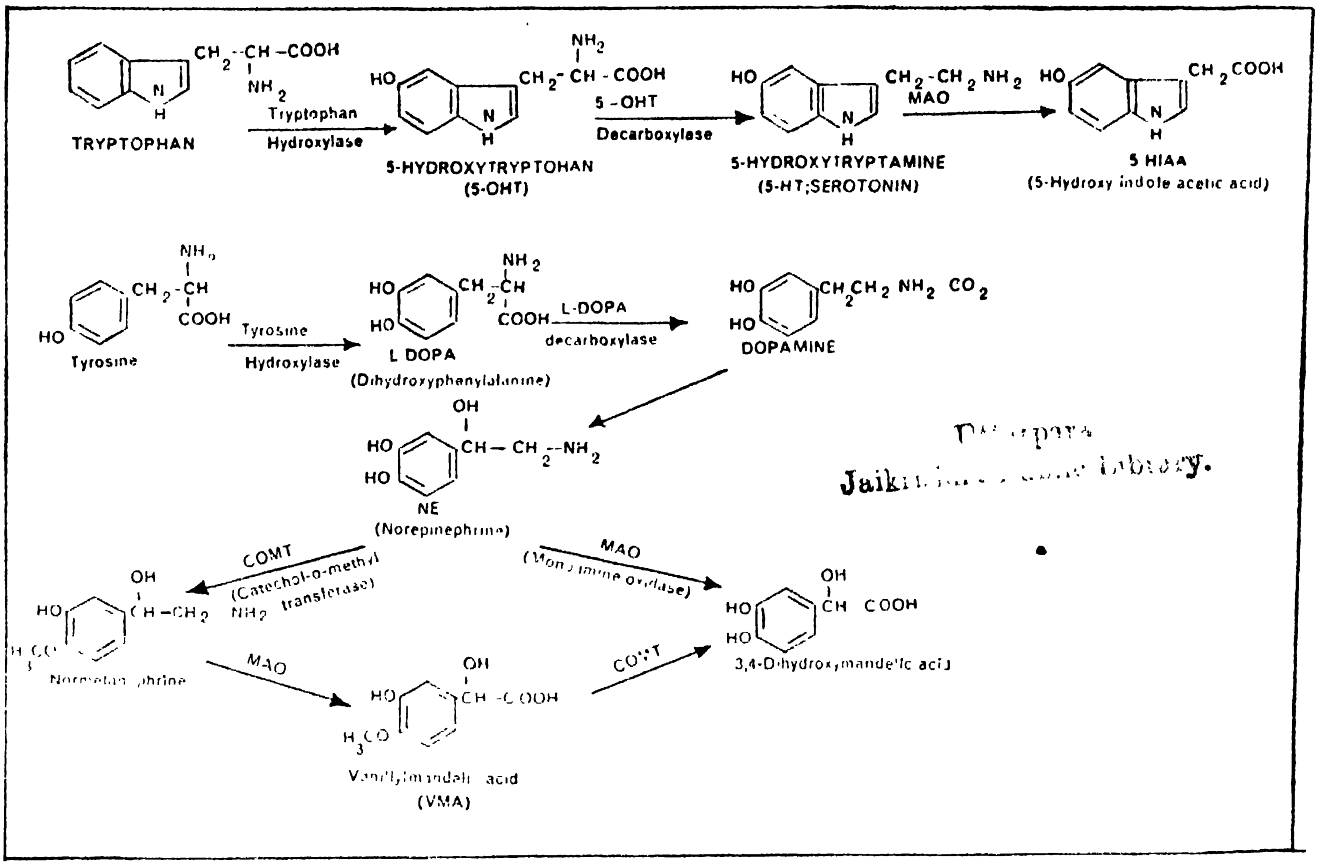
TRYPTOPHAN
Tryptophan Hydroxylase
5-HYDROXYTRYPTOHAN (5-OHT)
5-OHT Decarboxylase
5-HYDROXYTRYPTAMINE (5-HT;SEROTONIN)
MAO
5 HIAA (5-Hydroxy indole acetic acid)
Tyrosine
Tyrosine Hydroxylase
L DOPA (Dihydroxyphenylalanine)
L-DOPA decarboxylase
DOPAMINE
NE (Norepinephrine)
COMT (Catechol-o-methyl transferase)
MAO (Monoamine oxidase)
Normetanephrine
Vanillylmandelic acid (VMA)
3,4-Dihydroxymandelic acid

Fig. 5. Biosynthesis and degradation of some neurotransmitters

emotional states from the study of urinary metabolites of these compounds.

The major evidence concerning role of catecholamines in emotion comes from pharmacological studies. The action of reserpine has been extensively studied both *in vivo* as well as *in vitro*. This had led to the finding that the drug affects neuronal binding of catecholamines and serotonin. Thus, in the presence of reserpine, these amines become more accessible to monoamine oxidase—one of the enzymes which destroys these amines. It has been conclusively proved that reserpine-induced sedation in animals is related to decreased brain levels of norepinephrine, dopamine and serotonin. When only serotonin content of the brain is lowered, as in the case of PCPA administration, there is no sedation. Tyrosine hydroxylase inhibitors (e.g., α-methyl-*p*-tyrosine) selectively reduce catecholamine synthesis and produce sedation. All these studies point to the fact that the catecholamine content is of considerable significance in mental states in animals.

Parallel evidence has been obtained from studies with MAO inhibitors. These studies indicate that drugs such as iproniazid or imipramine (Tofranil) exert antidepressant action by raising the amine levels in brain. Amphetamine (Methadrine) has also a similar effect on the catecholamine content of the brain.

While there is lowering of catecholamines in brain in depressed states, the catecholamine content of the brain is raised in excited states and in mania. This has been further substantiated by systematic clinical investigations on patients suffering from mania and depression. Urinary excretion of catecholamines and their metabolites is changed in patients suffering from manic depressive illnesses. When patients suffering from depression are given antidepressant drugs which increase the catecholamine content of brain, the excretion of metanephrine and normetanephrine gradually increases with behavioral improvement. Alteration in the excretion of serotonin and its metabolites has also been reported in emotional disorders.

Biochemistry of schizophrenia

Schizophrenia presents one of the most challenging problems in mental disorders. Over the last few years, the disease has attracted considerable attention of the biochemists. Schizophrenia is characterized by a specific type of thinking, feeling and

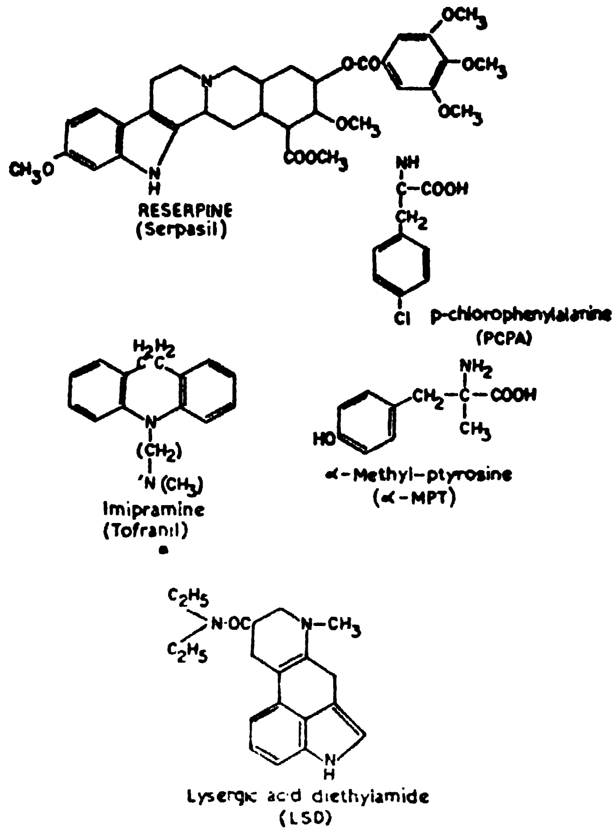

Fig. 6. Structure of some psychopharmacological drugs

relationship to the society which normaly does not occur in individuals.

Many workers have suggested that schizophrenia results from a defective serotonin metabolism. A number of metabolites of serotonin and some indole compounds resembling serotonin can produce transient schizophrenia-like states. On the other hand, some of the schizophrenic symptoms are alleviated by large doses of tryptophan, a precursor of serotonin. Studies carried out by H.E. Himwich of the Thudichum Psychiatric Research Laboratory, Illinois, U.S.A., showed that behavioral worsening in the schizophrenics was preceded and accompanied by a rise in urinary tryptamine. He has proposed that tryptamine combines with methyl groups to form a psychogenic compound which acts as an endogenous metabolic factor in the aggravation of schizophrenic symptoms. This is supported by observations indicating the presence of *N:N*-dimethyltryptamine and 5-methoxy *N:N*-dimethyl tryptamine in the urine of such patients just before and during the period of worsening of schizophrenic symptoms (Fig. 5).

Some investigators have suggested that there is a change in plasma protein composition of schizophrenic subjects. They have isolated a unique globulin named taraxein from the schizophrenic patients. When taraxein is injected into normal persons, schizophrenia-like symptoms are developed which last for several hours. R.G. Health and his associates of the Tulane University School of Medicine, New Orleans, U.S.A. have suggested that an antigen of taraxein may be present in the glial cells of brain, a suggestion which further stresses the importance of glial cells in brain function.

In 1952, it was proposed that schizophrenia might be associated with an abnormal metabolite of catecholamines such as 3,4-dimethoxyphenylethanolamine (DMPEA) which might have psychogenic properties like its close chemical relative mescaline. A.J. Friedhoff of the New York University School of Medicine actually obtained this compound in 1962 (Fig. 6) by paper chromatography from the urine of schizophrenic patients. It is referred to as "pink spot" due to its colour on paper chromatograms on staining with ninhydrin. Recent work, however, casts some doubt about the relation of DMPEA to mental disorders.

Conclusion

In recent years considerable progress has been made in the understanding of brain function in biochemical terms. Now it is possible to say that behaviour is a result of a number of integrated molecular events in the brain. Changes in these behaviour patterns due to changes in chemical reactions are called mental disorders. There is sufficient evidence to conclude that biogenic amines play an important role in the functioning of brain. It is now possible to artificially alter mood and behavior of an individual by affecting amine levels of his brain by drugs, many of which have

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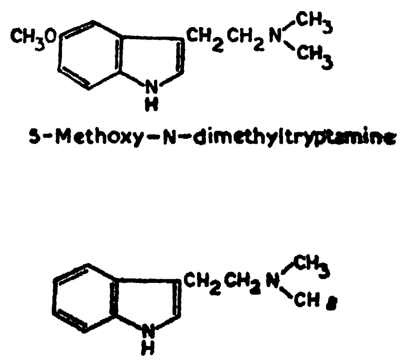

Fig. 7. Structure of methylated metabolites of serotonin

THE CHEMISTRY OF FREE RADICALS

SUKUMAR MAITI

SELDOM do organic reactions proceed from reactants to products directly; in most cases one or more intermediate species are involved. These intermediate species are, in general, very reactive and hence unstable. To understand the mechanism of a chemical reaction the study of such a reaction intermediate is very important. Free radical is an example of such species. Examples of reactions involving free radical intermediate are numerous. Two-thirds of polymers prepared in industry are by free radical processes. Moreover, polymer modifications such as cross-linking, grafting, block copolymerization, vulcanization of rubber, drying of paints and varnishes, polymer degradation, stabilization and autoxidation are all free radical reactions. Most photochemical reactions also proceed through radicals. In fact, free radicals were first discovered in the photochlorination of paraffins.

What is a free radical?

A free radical is an atom or a group of atoms with an unpaired electron. A hydrogen atom is the lightest and simplest example of a free radical. Due to the presence of a lone electron, the hydrogen atom is extremely reactive and unstable until it finds another species with a lone electron to form a pair. When two hydrogen atoms combine, a molecule of hydrogen is formed which is stable. The stability in the molecule of hydrogen results from the covalent bond formation by pairing of two lone electrons of the two hydrogen atoms. In other words, a stable covalent bond is the result of the union of two highly unstable and reactive free radicals.

Now, if a covalent bond between two atoms, say A and B, in a molecule ruptures in such a way that the two electrons of the covalent bond are shared equally between A and B, two free radicals, $A.$ and $B.$ will be generated.

$$A\text{——}B \xrightarrow[\text{breaks}]{\text{Bond}} A. + .B$$

This type of bond-breaking process is called *homolysis*. Therefore, free radicals are generated by the homolysis of covalent bond.

How free radicals are formed

Homolysis of covalent bonds may be initiated by (a) heat, (b) photochemical methods, (c) high energy

The high reactivity of free radicals make them valuable intermediates in a variety of chemical and biological processes

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irradiation, or (d) mechanical means. To cleave a covalent bond, the input energy must be greater than the *bond dissociation energy* which is a measure of the strength of the bond. And naturally the stronger the bond the higher would be the energy requirement for its rupture. The bond dissociation energies of a few covalent bonds are shown in Table 1.

Table 1. Bond dissociation energy of covalent bonds

Bond	*Bond dissociation energy (Kcals/Mole)*
O-H	110.6
H-H	104.2
C-H	98.8
N-H	93.4
C-C	83.1
S-H	81.1
Cl-Cl	58.0
S-S	50 9
Br-Br	46.1
N-N	38.4
O-O	33.2

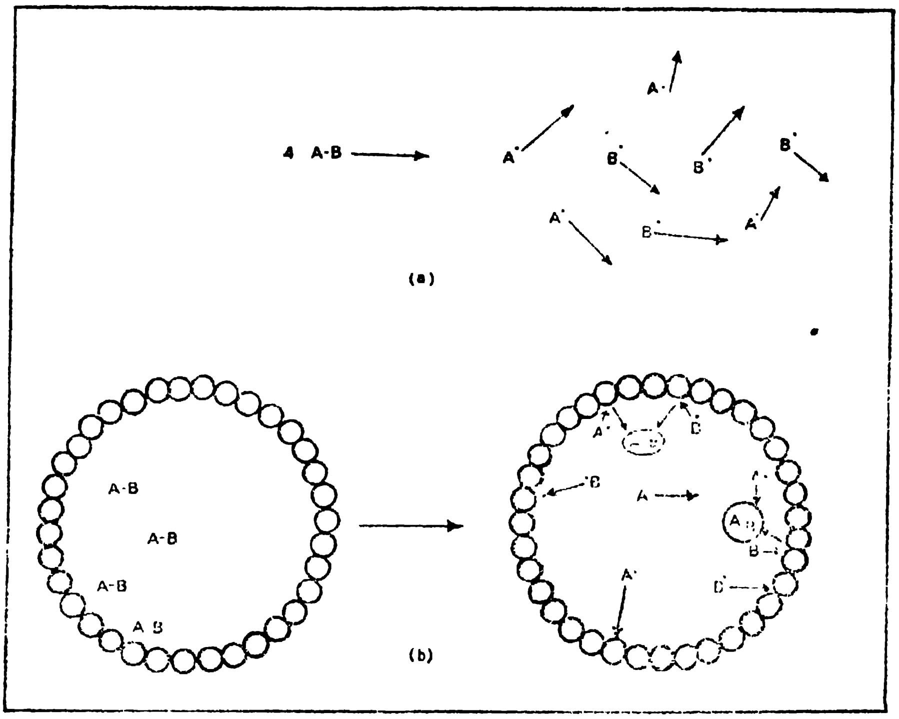


Fig. 1. Schematic representation of cage effect

To break a normal carbon-carbon or carbon-hydrogen covalent bond the input energy would be of the order of 100 Kcals/mole, or even higher. This is equivalent to the heating of a molecule to a temperature of around 800°C or more. So radical generation by thermolytic route from carbon-carbon or carbon-hydrogen bond is not practically suitable. But organic compounds containing relatively weak oxygen-oxygen bond, e.g., peroxides, per-esters, may easily be decomposed at moderate temperatures (60-120°C) to produce free radicals:

$$\text{R-O-O-R} \xrightarrow{\text{Heat}} \text{R-O.} + \text{R-O.}$$

Similarly organic azo compounds, disulfides, etc., also contain weak heat-labile bonds that can be conveniently ruptured by heat to produce free radicals. Since in such thermolysis only the weakes covalent bond in the molecule breaks, the structure of the free radica lsthus generated is known. This information is very important because the chemistry of the free radical depends to a great extent on its structure. Moreover, heat is the cheapest and most readily available energy source. That is why production of free radicals by thermal process is frequently followed in industry as well as in laboratory.

Ultraviolet light of 2,500-3,500 Å has got energy of the order of 82-112 Kcals/mole (see *Photochemistry, S.R.* June, 1972), which is sufficient to break most of the organic covalent bonds. So, exposing orga-

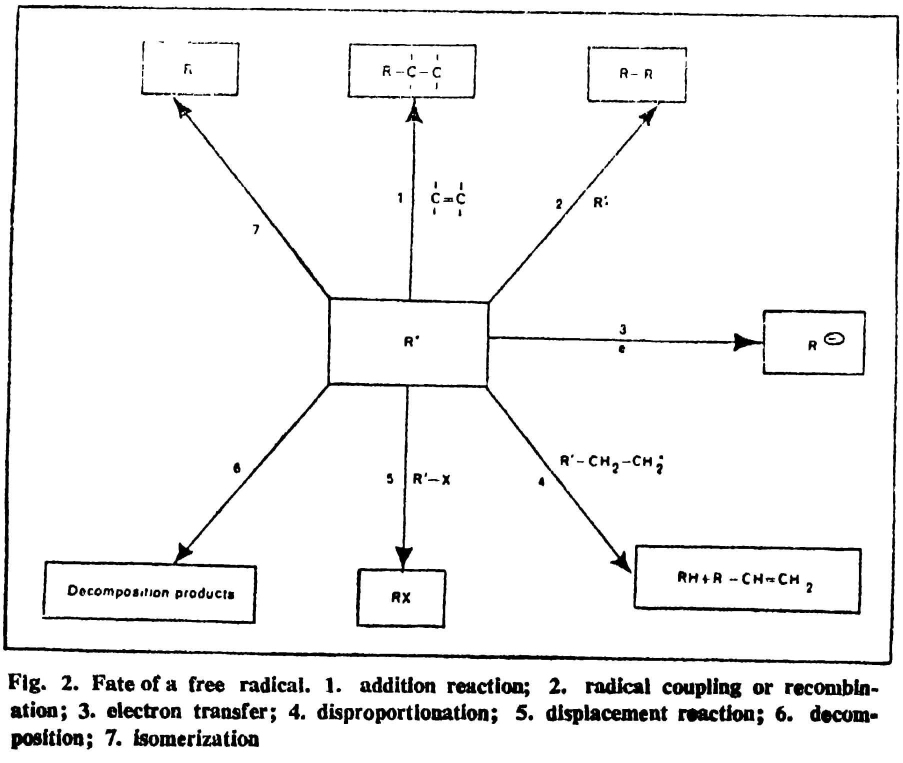


Fig. 2. Fate of a free radical. 1. addition reaction; 2. radical coupling or recombination; 3. electron transfer; 4. disproportionation; 5. displacement reaction; 6. decomposition; 7. isomerization

nic compounds to suitable ultraviolet light may initiate homolytic fission of the bond generating free radicals. For example, when a molecule of chlorine is irradiated with ultraviolet light, two chlorine atoms, which are in fact free radicals, are produced:

$$Cl_2 \xrightarrow{h\nu} 2\ Cl$$

Advantages of photochemical methods are high selectivity, easy control over radical generation and independence of temperature of the environment.

Exposure of organic molecules to high energy radiation such as x-rays or gamma rays does the same job as ultraviolet light does, but the former breaks the bonds in the molecule drastically and indiscriminately. Not only free radicals but a large number of complex fragments including ions are produced from such exposure. This process is, therefore, seldom used for radical production except in such systems where generation of radical site is often difficult by conventional methods. For example, production of radical site in the solid polymer is very often carried out by this process.

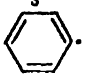
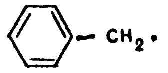
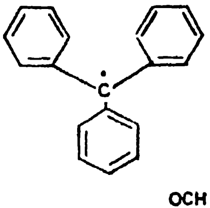
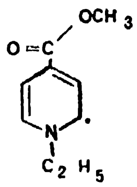
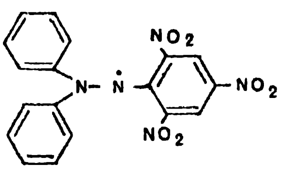
Another facile method of radical generation is by redox reactions. Many oxidation-reduction reactions proceed through one electron transfer. For example, redox reaction between ferrous iron and organic hydroperoxide produces free radicals:

$$Fe^{++} + RO{-}OH \longrightarrow Fe^{+++} + RO\cdot + OH^-$$

Life cycle of a free radical

Free radicals, in general, are short-lived. During their brief span of life they unergo various transformations and take part in many a chemical reaction until their radical site is destroyed. The birth of a free radical starts when a covalent bond is homolytically broken. There is no so-called incubation period for a free radical to attain maturity, i.e., full reactivity. A free radical is born with all the energy and vigour it should possess. Since free radicals generated by the fission of covalent bonds are formed in pairs there is every likelihood that they could couple and reform the covalent bond, particularly because the recombination of the radicals is a spontaneous, zero-activation energy process. While bond-breaking is a highly endothermic (i.e., energy-absorbing) process, bond-formation by radical combination is equally exothermic (i.e., energy-releasing). If the radical concentration in a particular vicinity is high, the chances of their encounter are also high and so also is the probability of regeneration of the parent compound. When free radicals are generated in gas phase reaction, they find enough free space to avoid effective collision with each other, and escape annihilation.

Table 2

Radical	Structure	Average life time
Methyl	$H_3C\cdot$	8.5x10^{-3} Sec.
Phenyl		~ 10^{-2} Sec.
Benzyl		~ 0.05 to 0.1 Sec.
Triphenylmethyl		quite stable
1-Ethyl-4-Carbomethoxy pyridinyl		1-2 days(in solution)
Diphenyl picrylhydrazyl		Indefinite as solid

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But when free radicals are produced in liquid phase the radicals are held, momentarily at least, by the cage and unless they diffuse out of it they collide with each other and die. This is known as *cage-effect* (Fig. 1). Free radicals can live only when their number in a particular area, i.e., concentration, is very small. The drama played by a free radical in different reactions before its death has been schematically represented in Fig. 2.

Structure and stability

The brief life-time of a free radical is due to the extreme reactivity of the lone electron and its tendency to form a covalent bond. Sometimes a free radical is so illusive that its existence is inferred only by ingenious methods. But there are examples of free radicals which are stable enough to be isolated. They are relatively less reactive and are called stable free radicals. The stability of a free radical, like all other species, depends on its structure. The stability may be increased in two ways: (1) by shielding the radical centre, and (2) by decreasing the probability of finding the radical centre in a particular position.

If the radical centre is sterically blocked by bulky groups so that it is effectively shielded from the attack of other radicals, the chance of radical destruction by combination is reduced, and consequently the life-span of the radical is increased.

When a radical has various resonating structures, the radical site (i.e., the lone electron) can roam about in any of these resonating froms and consequently the chance of finding it in one particular position is much smaller, and so its life-span is enhanced. The average life time of some radicals is given in Table 2.

Detection of free radicals

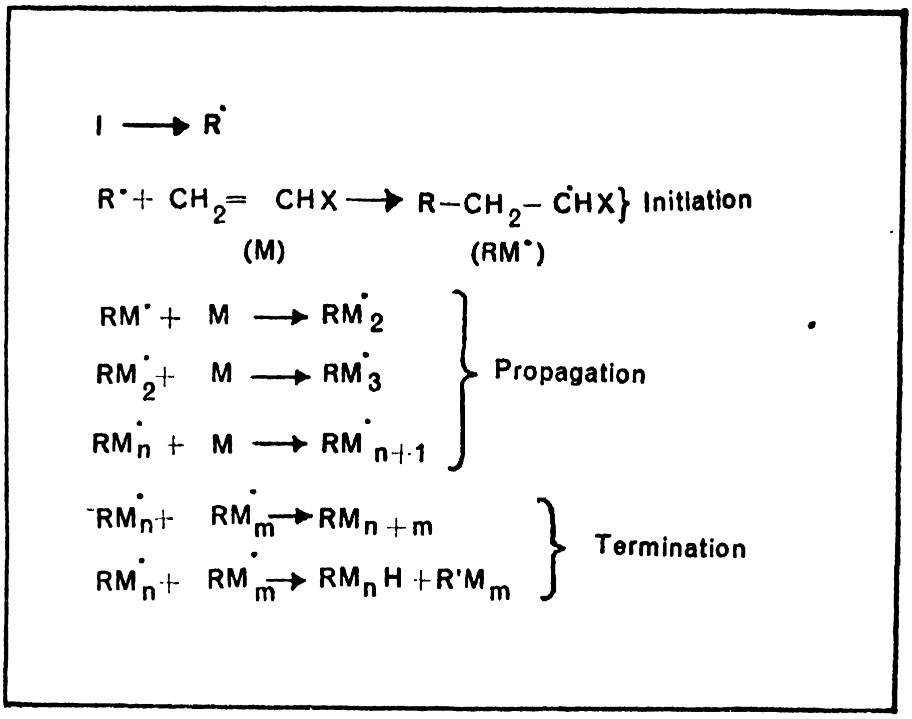
Since the life-time of most free radicals is brief their detection demands extremely sensitive techniques. A standard optical method is the coupling reaction with a stable highly coloured radical, such as diphenyl picryl hydrazyl, abbreviated as DPPH:

$$\underset{\text{Deep violet colour}}{\text{DPPH}+\text{R}^{\cdot}} \longrightarrow \underset{\text{Colourless}}{\text{DPPH-R}}$$

The decrease of the intensity of the violet coloured DPPH solution in presence of free radicals can be easily estimated spectrophotometrically.

Another elegant method of free radical detection depends on the paramagnetic property of the free radical, which is due to the presence of unpaired electron. Magnetic susceptibility measurement or electron spin resonance (ESR) spectroscopy could be used for radical detection.

Indirectly, presence of free radicals in a system may be inferred by introducing vinyl monomers capable of polymerization by free radical process. If polymerization occurs, the presence of free radical in the system is inferred.



$$\begin{aligned}
&\text{I} \longrightarrow \dot{\text{R}}\\
&\text{R}^{\cdot} + \underset{(\text{M})}{\text{CH}_2{=}\,\text{CHX}} \longrightarrow \underset{(\text{RM}^{\cdot})}{\text{R}-\text{CH}_2-\dot{\text{C}}\text{HX}} \Big\}\ \text{Initiation}\\
&\left.\begin{aligned}
\text{RM}^{\cdot} + \text{M} &\longrightarrow \text{R}\dot{\text{M}}_2\\
\text{R}\dot{\text{M}}_2 + \text{M} &\longrightarrow \text{R}\dot{\text{M}}_3\\
\text{R}\dot{\text{M}}_n + \text{M} &\longrightarrow \text{R}\dot{\text{M}}_{n+1}
\end{aligned}\right\}\ \text{Propagation}\\
&\left.\begin{aligned}
\text{R}\dot{\text{M}}_n + \text{R}\dot{\text{M}}_m &\longrightarrow \text{RM}_{n+m}\\
\text{R}\dot{\text{M}}_n + \text{R}\dot{\text{M}}_m &\longrightarrow \text{RM}_n\text{H} + \text{R'M}_m
\end{aligned}\right\}\ \text{Termination}
\end{aligned}$$

Fig. 3. Mechanism of free radical vinyl polymerization

Role of free radicals in industry

Polymer industry. One of the most important uses of free radical reactions is in the polymer industry. More than two-thirds of polymers manufactured in industry are addition polymers that involve free radical pathways. Much of the free radical chemistry, in fact, has been developed from the study of vinyl polymerization. The mechanism of free radical vinyl polymerization has been represented in Fig. 3.

Not only polymer formation follows free radical route, polymer degradation also proceeds through the same free radical reaction intermediate. The degradation of polymers is the sum of two competing processes: chain scission and cross-linking. The former process results in the reduction of molecular weight and consequently in the deterioration of the mechanical properties of the polymer. Cross-linking of chains develops stiffness in the chain, and eventually leads to brittleness of the polymer. These two deleterious effects are triggered on by free radicals formed by the atmospheric oxidation of polymers (Fig. 4).

The process of retardation or complete inhibition of such deleterious effects of polymer degradation is very useful in industry, and is known as stabilization of polymers. Compounds that may act as radical traps by reacting with radicals to form either non-radical products or stable radicals have been used as polymer stabilizer. Aromatic amines, substituted phenols, naphthols, etc., are examples of stabilizers used in polymer industry. The mode of action of such stabilizers is shown in Fig. 5.

Modification of polymers also mostly involves free radicals. Formation of copolymers by simultaneous polymerization of two or more different monomers, block and graft copolymerization, and curing

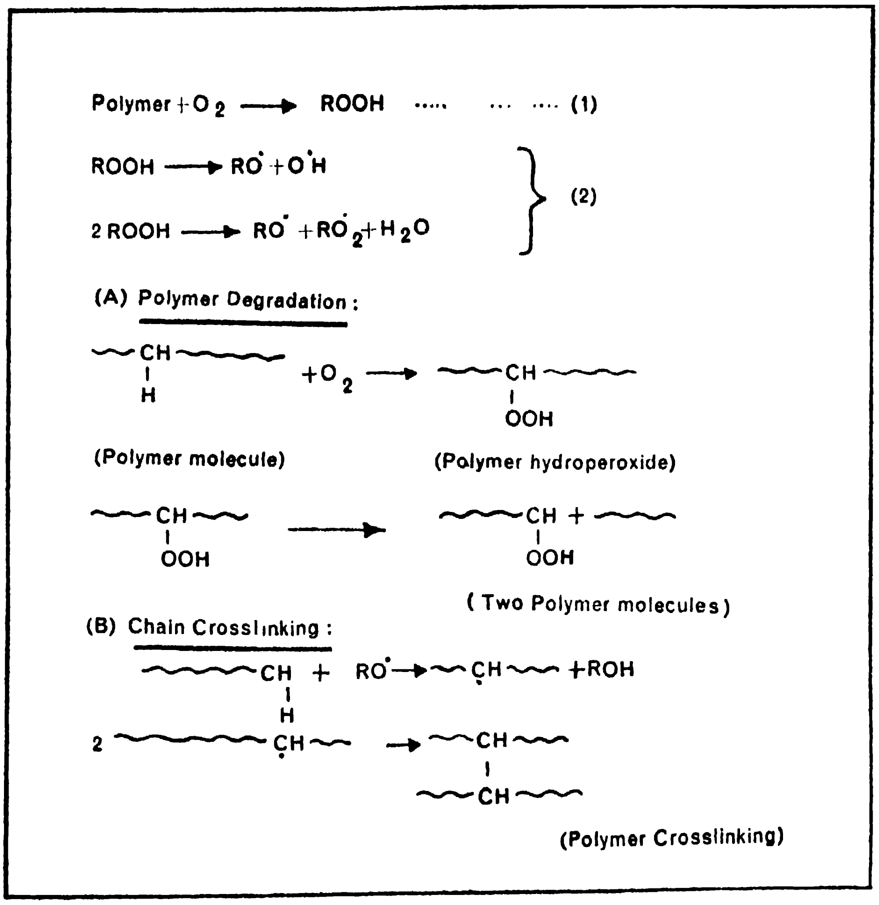

Polymer + O2 → ROOH .... (1)
ROOH → RO˙ + O˙H
2 ROOH → RO˙ + RO˙2 + H2O
(2)
(A) Polymer Degradation :
(Polymer molecule)
(Polymer hydroperoxide)
(Two Polymer molecules)
(B) Chain Crosslinking :
+ROH
(Polymer Crosslinking)

Fig. 4. Polymer degradation and cross-linking

or cross-linking of polymers are carried out by free radicals. Hardening of epoxy resins, drying of polymer-based paints, and vulcanization of rubber are examples of polymer cross-linking so important in industry.

Biological processes. The role of free radicals in various biological processes has recently been reported by many workers. The aging of animals including human beings is now considered to be due to a complex process involving free radicals. Collagen, the structural material of the body, is composed of linear long chain molecules, which accounts for the elasticity, flexibility and resilience of the tissues that shape the body. With age the body becomes stiff, less flexible and loses shapes and forms that make the body beautiful and attractive. This has been explained as due to the cross-linking of the adjacent collagen fibres by some free radical reaction similar to polymer cross-linking. It is reasonable to assume, then, that if bio-cross-linking process can be disrupted or retarded by radical inhibition the aging phenomenon may be delayed.

Not only polymer degradation and decomposition are free radical processes, but the decomposition of food, and the rancidity of butter also involves free radicals. Like polymer stabilization, food is prescribed by adding free radical inhibitors such as butylated hydroxy toluene (BHT).

Radiation chemistry. The process of high energy irradiation of organic systems involves, among a host of other reactive intermediates, free radicals. In biological species such a radiation process causes severe damage to the system.

This damage to cell and consequently to the living organism proceeds also through free radical pathways. Hence, to protect living cells from radiation damage substances that can react with free radicals to form harmless products in the environment of the body would be effective. Sulfur compounds containing —SH or —S—S—group are such active protective compounds. These groups readily react with free radicals and form harmless products.

Photochemical processes. Most photochemical reactions involve free radicals. Photo-halogenation of

(*Continued on page 260*)

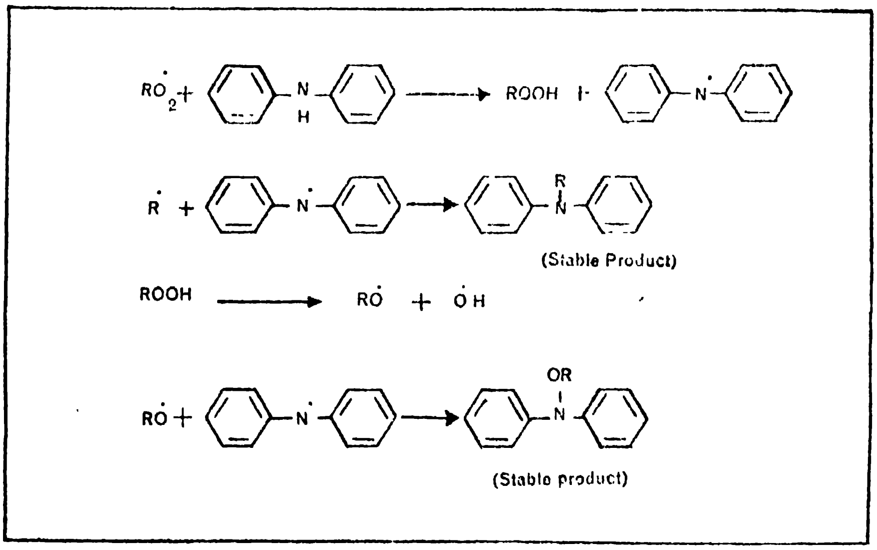


Fig. 5. Polymer stabilization

SLAG-CERAMS:
Ceramic Products from Slag

HEM SHANKAR RAY

Versatile ceramic materials, produced through controlled crystallization of the predominantly glassy slag, are the latest in slag research

NOT very long ago the general attitude towards possible uses of metallurgical slags was reflected in the popular saying—'if you put enough of it in a hole, you will fill the hole'. Things have, however, changed a great deal in recent years. Today industrial slags, such as those produced by iron and steel plants, find manifold uses. Slag-ceram or ceramic product from slag is the latest outcome of intensive research on slags.

Huge quantities of slags are produced by metallurgical plants, specially the integrated iron and steel plants. Particularly large quantities are produced during pig iron production by the blast furnaces wherein the gangue in iron ore is removed through fluxing. In technologically developed countries such as the U.S.A., West Germany and Japan, the slag yield amounts to 300-500 kg per ton of pig iron. In India poorer raw materials and less efficient operation results in larger slag output—some 600-800 kg per ton of pig iron. Over the period of months, slag output amounts to millions of tons and constitutes a formidable problem of waste disposal.

Efficient utilization of slag would not only help solve the problem of disposal and save valuable space but would also earn profits for the plant. Today a large number of uses for slags have been found and search for newer applications continues.

Uses of slag

Substantial amounts of slag are used as railroad ballast, dense aggregate in concrete, porous aggregate in foamed form for light weight concrete, soil conditioner, slag wool, cement in granulated form, etc. Open hearth slag may be used as a cheap fertilizer because of its phosphorus content. Blast furnace slag does not contain phosphorus, however, it may be used as soil conditioner to impart basicity to soil.

Large scale development of slag market started after the First World War when iron and steel production showed marked rise in the more developed countries. Proper foresight of planners in these countries led to utilization of larger and larger quantities of slags for various useful purposes. Today several countries

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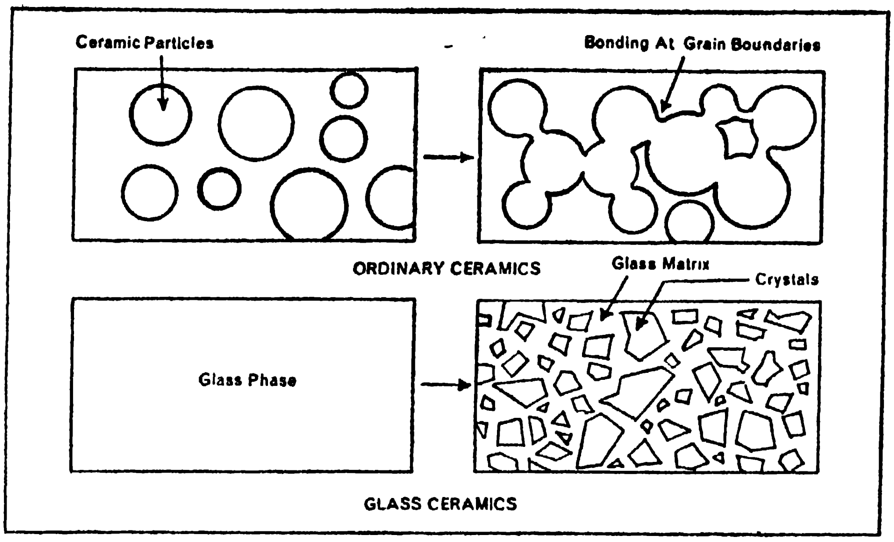


Fig. 1

such as the U.S.A. and West Germany not only use all the slags they produce but also regularly utilize slag from old waste dumps. Eventually, therefore, there would be no slag dumps in the steel plants of these countries. In the U.K. and U.S.S.R more than fifty per cent of the slag is utilized profitably. In some countries, e.g., Hungary, the governments have made utilization of slag compulsory. India, unfortunately, is far behind in this area of waste utilization and not even ten per cent of slags produced find any useful application. Consequently, all steel plants in the country are producing slag hills around plant sites.

Slag-ceram

Ceramic products from predominantly glassy slag are the latest in slag research. A ceramic material, provisionally called slag-ceram, can be produced through controlled crystallization of slag-based glass. The British Iron and Steel Research Association (BISRA), among other organizations, has played a pioneering role in the development of this new material.

Slag-ceram is a material which belongs to the general category of glass ceramics. In the manufacture of ordinary glass, great care is taken to ensure that no crystals from the raw materials either remain or are formed. On the other hand, glass ceramics are produced by almost complete crystallization of a body made from a special glass. In a way this process may be regarded as the opposite of that for the production of ordinary ceramics where a body of largely crystalline particles is heated until enough glass is produced to bind the particles together. The difference is schematically indicated in Fig. 1.

Slag-ceram can be regarded as a new form of glass ceramic having an exceptionally complex composition and suited to a tonnage market. It is produced by the fine and uniform crystallization of glass made from metallurgical slag. Blast furnace slags, for example, are largely glass with some solid crystalline constituents. First they are completely glassified by adding additional amounts of silica or alumina. This glass is then subjected to controlled crystallization for producing slag-ceram.

Available literature on slag-ceram is rather limited. This is partly due to the fact that research and development work in this area is still in the initial stages. Moreover, most research organizations have kept their findings secret to safeguard the commercial potential of the products they are developing. It is, however, known that so far the material has

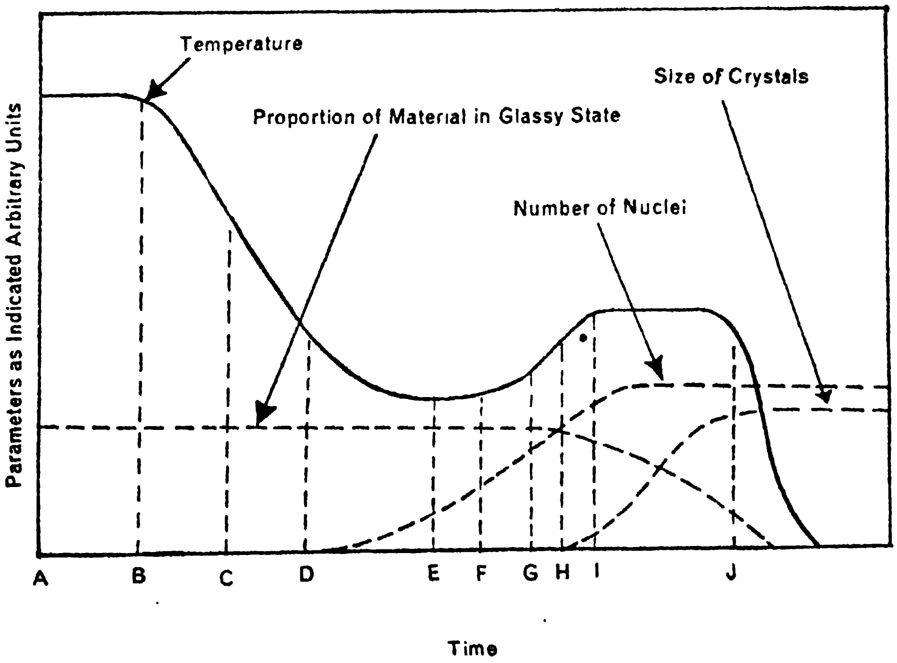


Fig. 2. Steps in heat treatment for slag-ceram production

been in commercial production only in small scale in the U.K., U.S.S.R., and Japan. The production costs are presumably high and the market is restricted to special wear-resisting shapes.

Production

Slag-ceram production requires complete crystallization of slag to form fine (of the order of 1-20 μm) crystals of reasonably uniform size. It is on these features that the specially desirable properties of slag-ceram depend. The essence of the technique is to have a slag-glass composition that generates a large number of nuclei, i.e., centres of crystallization, uniformly in any region of the glass body before appreciable crystal growth starts on them. The process, therefore, involves two stages—nucleation and grain growth. With various nucleating agents, degrees of oxidation and other factors, a considerable range of colours can be obtained, e.g., orange, brown, off-white, etc.

To produce slag-ceram, the parent glass phase is first held for some time at a suitable temperature to generate a large number of nuclei. At this temperature the growth of nuclei is small. Subsequently, the temperature is raised to allow the nuclei to grow so that almost the entire bulk finally consists of fine crystals. A typical heat treatment procedure is shown in Fig. 2. Before the region *A*, a completely glassy slag is obtained by adding glass formers such as silica or alumina. A popular procedure involves addition of 30 parts of silica by weight to 100 parts of blast furnace slag. The mixture is melted and homogenized using suitable nucleating agents. Nuclei-formers may be transition metal oxides and sulphides, chrome ore containing Cr_2O_3, various forms of iron oxides, etc. Sometimes coke is added to control the state of oxidation of the melt to which the nucleation phenomenon is sensitive.

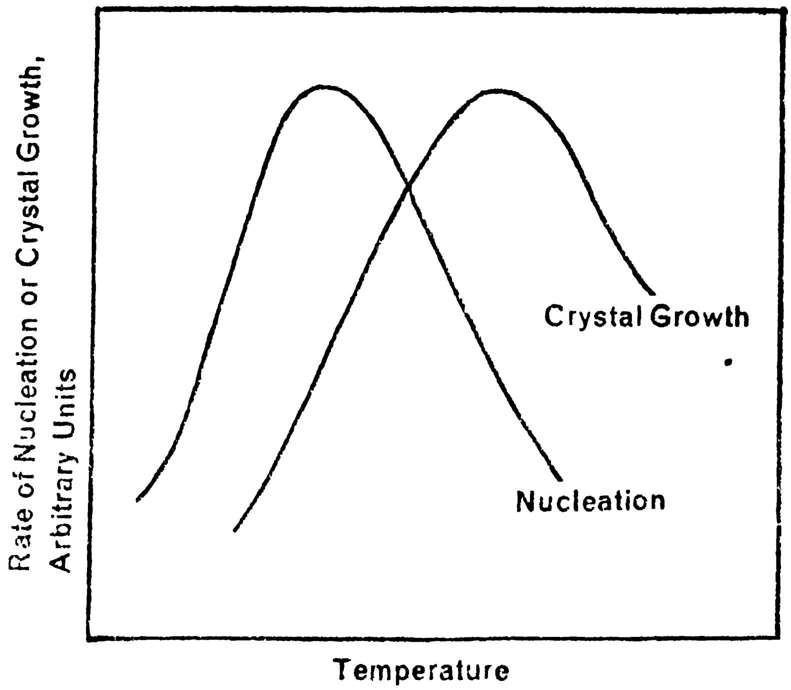


Fig. 3. Temperature dependence of nucleation and crystal growth

In the region *A-B*, the molten glass is brought to uniform consistency, in *B-C* the temperature is reduced to that suitable for casting articles of desired shapes, shaping being carried out at *C*. The article is then cooled (*C-E*) and the temperature held at a level *E-F* where the rate of nucleation is large. A large number of crystallization centres are produced in the bulk although there is still no actual crystallization. Nucleus formation starts at *D* and persists upto *H*. Crystal growth starts after *G* when the temperature is raised and the nuclei are increasingly enclosed in crystals. The temperature is finally held constant at the level *I-J* to allow maximum growth rate for crystals. The article is then cooled slowly.

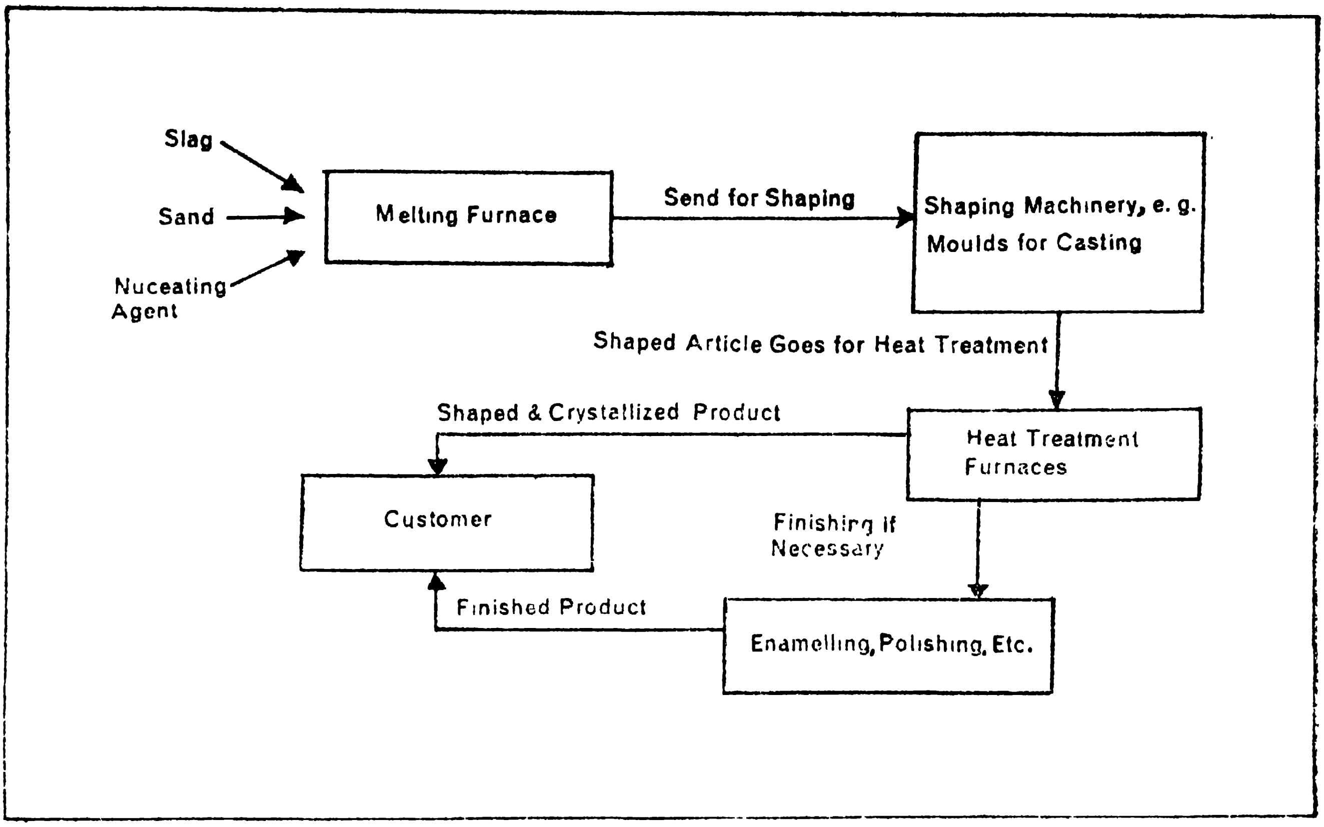
Theoretical considerations and experimental investigations show that the maximum rate of nucleation and that for crystal growth are obtained at two different temperatures, the latter being somewhat higher. This is schematically shown in Fig. 3.

The separation of the two peaks implies that for fast operation, the glass slag should first be subjected to annealing at a lower temperature for nucleation and then subjected to high temperature annealing for crystal growth. The actual temperatures can be ascertained only through systematic trials.

A typical flow sheet for producing slag-ceram products is shown in Fig. 4. The two most important parameters of operation at each stage are temperature and holding time. These depend on a large number of factors such as glass composition, volume of product, nature of properties desired, etc. These can be determined only through repeated experimentation.

Properties of slag ceramics

The most noticeable characteristic of slag ceramics is their extremely fine grain size. It is this feature which is the basis of most valuable properties of the material. Between the crystals is present a small amount of residual glass phase and,



Slag
Sand
Nuceating Agent
Melting Furnace
Send for Shaping
Shaping Machinery, e. g. Moulds for Casting
Shaped Article Goes for Heat Treatment
Heat Treatment Furnaces
Shaped & Crystallized Product
Customer
Finishing if Necessary
Finished Product
Enamelling, Polishing, Etc.

Fig 4. Flow sheet for production of slag-ceram articles

although this may be no more than a few per cent, it is believed that this has an important influence on the physical properties of the material.

Mechanical properties. At room temperature glass ceramics, like ordinary glasses and ceramics, are brittle materials exhibiting no region of ductility or plasticity. They show perfect elastic behaviour upto the stress which causes failure. Glass ceramics, however, withstand far greater stresses.

Strength of ordinary glass is greatly dependent upon surface flaws known as Griffith's cracks. These minute cracks on the surface act as stress multipliers and propagate under low stresses to cause yielding of the material. Griffith's cracks reduce the strength of ordinary glass from a theoretical value of about a million psi to about 10,000 psi. (psi = pounds per sq. in.). Generally the corresponding glass ceramics may be 5-10 times stronger. Higher strength is attributed to the role of crystal boundaries in diverting propagating cracks, slowing them down or even stopping them entirely. In addition to increased crushing strength, slag-cerams also exhibit increased density, scratch-hardness and excellent wear resistance. All this is due to crystal formation. The density increase due to formation of dense crystals is sometimes offset by the development of internal pores during nucleation and crystallization. It should be remembered, however, that pores are far more common in conventional ceramics where they weaken the material.

Thermal properties. Dimensional changes which occur in ceramic material due to change in temperature, are of great importance from several points of view. First, the coefficient of thermal expansion should be as low as possible to minimize strain resulting from temperature gradients within the material. Second, a material joined to a different material must have a closely matching thermal expansion coefficient to prevent cracking of the joint on thermal changes. An amazing range of glass ceramics are available with thermal expansion coefficient as low as zero.

Uses of slag-ceram

Comparable to conventional ceramics in many ways, slag-ceram articles are of potential use in many applications. They would be particularly valuable in residential and commercial construction work where wear resistance is an important advantage. Slag-cerams may find use as tiles, wall panels and partitions. Their strength, light weight and fire resistance ensure a wide range of use as a refractory facing or flooring material. Other uses would include ex-

(*Continued on page 239*)

NUTRITIVE VALUE OF PROTEINS

R. KRISHNA RAO

What is required for a good diet is not just any protein but one that is well balanced in essential amino acids and has a higher biological value and protein efficiency ratio

PROTEINS are complex nitrogenous compounds present in all living cells and perform most important functions of the cell. A few examples of protein compounds are the enzymes which catalyse many of the reactions in the cell, some hormones which regulate the metabolic processes, antibodies which are produced in the body to fight the invading agents, viruses responsible for many diseases in animals, plants and microorganisms, and haemoglobin, the red pigment of blood cells. All proteins on hydrolysis either by acid or by enzymes give 22 amino acids. They are glycine, alanine, valine, leucine, isoleucine, serine, threonine, phenylalanine, tyrosine, trytophan, cysteine, cystine, methionine, . aspartic acid, glutamic acid, lysine, hydroxylysine, arginine, citrulline, histidine, proline and hydroxyproline. The differences in the proteins arise out of different quantities of the amino acids that go in for the synthesis of the protein and also the pattern of linkages.

The amount of protein present in a food is often determined by estimating the nitrogen content and multiplying it with the factor 6.25. A protein molecule on an average contains 16 per cent nitrogen, and hence the amount of nitrogen multiplied by 6.25 gives the amount of protein. The actual amount of nitrogen varies from one protein to another by a small margin from 16 per cent, but the use of the factor 6.25 does not bring in much error. The nitrogen content is determined by Kjeldahl's method.

Metabolites of nitrogen

In the body, the tissue proteins are constantly being broken down and an amino acid pool is formed. The dietary proteins, on hydrolysis, give rise to amino acids which are absorbed into the system and join the amino acid pool. Tissue protein synthesis takes place from this pool. The tissue proteins which are most essential are synthesised first. The amino acids which are not utilised in tissue protein synthesis are metabolised and the metabolic end product, urea, is excreted in urine. The tissue protein breakdown can

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be measured by determining the nitrogen excreted in faeces and urine on a protein-free diet. The nitrogen excreted in faeces comes from the residual digestive juices, intestinal microflora and cells of the mucosa of intestinal lining. This may be called 'metabolic nitrogen' (MN). The nitrogen excreted in urine on protein-free diet comes from the metabolic processes of those amino acids of the amino acid pool which are not utilised for anabolic processes. This can be called 'endogenous urinary nitrogen' (EUN). When a diet containing protein is used there are greater quantities of nitrogen excreted in faeces and urine. The 'total fecal nitrogen' (TFN), which is the nitrogen excreted in faeces on protein diet, contains MN and the undigested and unabsorbed nitrogen of food protein. The 'total urinary nitrogen' (TUN), which is the nitrogen excreted in urine on protein diet, comprises EUN and the nitrogen of amino acids that are absorbed from food protein but not utilised in tissue protein synthesis.

Tissue protein synthesis is a rapid process requiring all amino acids in balanced proportions to be present at the same time. The amino acids are broadly classified as essential and non-essential depending upon the ability of the body to synthesize. Those which cannot be synthesized and are to be supplied through food are called essential amino acids. They are: methionine, phenylalanine, valine, isoleucine, lysine, leucine, tryptophan and threonine. For tissue protein synthesis all the amino acids, both essential and non-essential, must be present at the same time in a balanced proportion. A delayed supplement does not help as by then the other amino acids are already metabolised. The practical significance of the time factor in protein metabolism is that a proper distribution of dietary protein both regarding quality and quantity among the different meals is essential for the best utilization of dietary protein. The amino acids also should be in proper proportions. The requirements of tryptophan are enhanced in the presence of large quantities of threonine and phenylalanine in the dietary protein.

As proteins are different from one another in many ways, their biological utilization is also different. The biological utilization can be studied to differentiate one protein from another. The most important function of the dietary proteins is to provide a mixture of amino acids of the proper proportions and pattern for synthesis of tissue proteins. Any method of evaluating the utilization of proteins makes use of this function only. There are a number of methods for evaluating the nutritive value of proteins, the most common amongst them being the 'protein efficiency ratio' (PER) and the 'biological value' (BV). Other methods include chemical score, determination of the gain in caracass protein, total protein of plasma, total haemoglobin, filling the liver protein compartment and the study of enzymes in liver.

Protein efficiency ratio

Protein efficiency ratio is defined as the gain in weight per gram of protein consumed. It is determined by growth studies. Growth is a term that is used to refer to a number of ways in which living systems may increase in size. Normal growth is an integrated process in which a nice balance is maintained between all the tissues. It can be correlated with an increase in weight or increase in body protein. PER is determined by feeding a protein diet to young albino rats for a period of four weeks. The initial weights of the rats are recorded. The rats are given weighed amounts of the protein diet whose PER is to be determined. The residual amount of food is collected separately into bottles. Water is allowed *ad libitum.* The rats are weighed again at the end of the experimental period and from it the gain in weight is calculated. From the amount of food consumed, the amount of protein and finally the PER are calculated. The higher the value of PER, the better is the quality of protein. Usually foods of animal origin have higher PER values. The PER of some of the common foods is shown in Table 1.

Another common method of evaluating the nutritional quality of protein is by the nitrogen balance or biological value method. In this method adult albino rats are housed in individual metabolic cages. The animals are given protein-free diet prepared by mixing the ingredients in a definite proportion. The animals are allowed to get used to the new diet for four days. During this period the breakdown of tissue protein falls rapidly to a constant level and is maintained at that level. During the next three days, the urine and fecal matter is collected separately and the amount of nitrogen excreted in it is determined by Kjeldahl's method, thus recording MN and EUN. The animals are given one week's rest during which normal diet containing more than 18 per cent protein is fed. The protein diet whose BV is to be determined is prepared by taking the food in the required proportion and mixing with protein-free diet. This food is fed to the same rats again. They are allowed to get themselves adjusted to the new diet for a period of four days. On the last three days of the week faeces, urine and the residual amount of food are collected separately for each of the rats. The amounts of nitrogen excreted in urine (TUN) and TFN, and the amount of nitrogen intake per day are calculated.

Table 1

Sl. No.	Food	Biological value (BV)	Protein efficiency ratio (PER)
1.	Barley	71	..
2.	Maize	60	1.0
3.	Ragi	89	0.7
4.	Rice, raw, milled	80	1.7
5.	Wheat, whole	66	1.3
6.	Bengalgram pulse	61	1.1
7.	Blackgram	63	1 0
8.	Greengram	54	0.8
9.	Khesari pulse	47	0.3
10.	Lentils	49	0.5
11.	Peas	59	1.1
12.	Redgram	72	0.7
13.	Soybean	60	0.9
14.	Amaranth leaves	72	..
15.	Drumstick leaves	41	..
16.	Ipomea leaves	67	..
17.	Mustard leaves	84	..
18.	Spinach	87	..
19.	Potato	68	1.9
20.	Sweet potato	72	1.5
21.	Brinjal	71	..
22.	Ladies fingers	82	..
23.	Coconut	77	1.0
24.	Gingelly seeds	67	1.0
25.	Groundnut, roasted	56	..
26.	Beef muscle	69	..
27.	Hen's egg	95	3.8
28.	Goat meat	60	..
29.	Cow's milk	82	2.0
30.	Buffalo milk	67	2.0
31.	Goat milk	68	1.0
32.	Skimmed milk powder	83	..
33.	Katla fish	78	1.8
34.	Prawns	67	..
35.	Koi fish	87	..
36.	Mrigal fish	72	1.7

BV, i.e., the percentage of absorbed nitrogen retained in the body is then determined from the formula:

$$BV = 100 \times \frac{\text{N retained}}{\text{N absorbed}}$$

$$= 100 \times \frac{\text{N absorbed—N not retained}}{\text{N absorbed}}$$

$$= 100 \times \frac{[\text{N intake—(TFN—MN)}]\text{— (TUN—EUN)}}{\text{N intake—(TFN—MN)}}$$

Higher the biological value, better is the quality of the protein. The biological value of some of the proteins is given in Table 1.

Various factors influence the biological utilization of proteins. Among them are: (1) the essential amino acid content of the food protein, (2) amino acid link up or make up, i.e., the graphical pattern in which the amino acids are linked to each other, (3) the presence of antidigestive factors naturally associated with the food which do not allow digestive enzymes to perform their functions efficiently and completely, (4) presence of some amino acids in larger quantities which creates deficiency of other amino acids thereby affecting the anabolic processes, (5) presence of all the amino acids at the same time for anabolic processes, (6) the amount of protein present in the diet (the higher the protein content of the diet the less is the efficiency with which the protein is utilized), and (7) sufficiency of calories from non-protein part of the diet. If the diet is deficient in calories some of the amino acids are metabolised to yield energy thereby disturbing the anabolic process. Sometimes chemical score method is also used to denote the quality of protein. For this, the total essential amino acid content of the protein is determined and the percentage of the most limiting amino acid (that which is found in the least quantity) to the total is calculated. The percentage of the same essential amino acid to the total essential amino acids in a reference protein (hen's egg protein may be taken as a standard reference protein) is calculated. The two percentages are compared. Generally methionine, together with cystine, lysine and tryptophan, is considered to determine the chemical scores. Hence a food may give three different values and it becomes difficult to judge the nutritional quality of the protein and compare it with others.

PER is the net result of the utilization of protein and can be considered to be a good index. BV, however, does not take into consideration the digestibility of the protein. Digestibility is the percentage of food nitrogen absorbed into the body. It can be expressed as :

$$\text{Digestibility} = 100 \times \frac{\text{Nitrogen intake} - (\text{TFN} - \text{MN})}{\text{Nitrogen intake}}$$

The chemical score method of evaluating the quality of protein does not take into consideration the presence or absence of amino acid imbalance, amino acid make up in the protein, digestibility, antigestive factors, etc. It is calculated only on the basis of chemical analysis of the protein. Hence it does not express the exact nutritive value of protein. Another index is, therefore, used to express the net utilization of the protein in biological systems. It is the net protein utilization in the biological system and expressed by the formula

$$NPU = 100 \times \frac{\text{Nitrogen intake} - (TFN - MN) - (TUN - EUN)}{\text{Nitrogen intake}}$$

Scientists have developed a rapid, accurate and useful method of evaluating the nutritive value of protein by first depleting and then repleting the protein stores in the adult rat. Depletion can be obtained by feeding the rat protein-free diet for a period till it loses 25 per cent of weight and then feeding the test diet and measuring the repletion. Excellent correlation has been obtained between gain in weight during repletion with regeneration of blood and liver or caracass proteins making the weight recovery alone a good measure of nutritive value.

Protein requirements are high during the growing stage. Deficiency in the growing stage leads to some permanent, degenerative changes. Pregnant ladies, lactating mothers, infants, and pre-school children need adequate quantities of good quality protein most.

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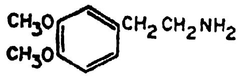
MENTAL DISORDERS

(*Continued from page 226*)



DMPEA

Fig. 6. Structure of DMPEA

found important place in clinical practice. With the help of these drugs it is now possible to treat and prevent many mental diseases at an early stage and many persons who would have otherwise become a burden to the society can now lead a fairly normal life.

However, in spite of these developments, still so much has to be done on the chemistry of brain. We as yet do not exactly know what biochemical changes take place during learning and how memory is stored in the brain. Exact aberration at the molecular level in schizophrenia is far from clear. Further researches on these problems will lead to a better understanding and treatment of mental disorders.

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SLAG-CERAM

(*Continued from page 235*)

ternal and internal walls of buildings, road paving, flights of stairs, corrugated roofing, sanitaryware, technical equipments, etc. Sheet-like slag-ceram panels reinforced with metal and coated with ceramic colours would have special attractions as architectural panels, decorative tiles for manifold uses, coloured sculptures, etc. Slag-cerams have given excellent performance as floor material in hot shops where hot objects are frequently dragged along the floor. All these merely indicate the diverse ways in which slag-ceram can be profitably used.

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SCIENCE SPECTRUM

Air ions and health

IN normal clean air over land, there are 1500 to 4000 ions/cm^3. Since negative ions are more mobile and the earth's surface has a negative charge, they are more easily repelled from the earth's surface. The normal ratio of positive to negative ions in the air close to earth's surface is about 1.2. Ion formation begins when enough energy acts on a gaseous molecule to eject an electron. Most of this energy comes from the radioactive substances in the earth's crust, and some from the cosmic rays. When the displaced electron is accepted by an adjacent molecule, a negative ion is formed, the original molecule then becoming a positive ion. Molecular collisions transfer the charge so that positive charges come to reside on molecules with the lowest ionisation potential, while electrons are attracted by the species of greatest stability. Next, neutral gas or water molecules cluster about the ions to form small air ions of four types: $H^+(H_2O)_n$, $(H_3O)^+(H_2O)_n$, O_2^- $(H_2O)_n$ and $(OH)^-$ $(H_2O)_n$, where n is a small number. Recent investigations show that the changes in the concentrations of air ions, or changes in the ratio of positively charged to negatively charged molecules in the air can have remarkable effects on plants, animals and even humans. From this standpoint, it is important to note the impact on human health of ion-depleted air as is often encountered in offices, industries and crowded rooms. Equally important is to realise that the modern city life which increases the ratio of positive to negative small air ions, can also be a factor of substantial concern to our health.

In a 14-day study in 1971 by B. Maczynski (*Int. J. Biometeor.*, Vol. 15, p. 11), an office containing four persons showed that the small air ion concentration dropped as the day went on, falling on average to only 34 positive ions and 20 negative ions/cm^3. A test at a light industry area of San Francisco by J.C. Beckett (*J. Amer. Soc. Heat Refrig. Air Cond.*, Vol. 1., p. 47) demonstrated a small-ion count of less then 80 ions/cm^3. In both cases, the number of physiologically inert large ions rose considerably—apparently small ions react with dust and pollutants to form large ions. People travelling to work in polluted air, spending eight hours in offices or factories, and living in urban dwellings in their leisure hours invariably breathe ion-depleted air for substantial portions of their lives. There is increasing evidence that this ion depletion leads to discomfort, enervation and lassitude and loss of physical and mental efficiency. This syndrome appears to develop quite apart from the direct toxic effects of the usual atmospheric pollutants. Addition of negative ions or both kinds of ions restores comfort and physiological normalcy. Back in 1939 three Japanese scientists, S. Kimura, M. Ashiba and L. Matsushima showed that if temperature, humidity and carbon dioxide levels were all kept at the comfort level, but the ion level was reduced, individuals suffered from symptoms such as perspiration and depression. In recent years it has been conclusively demonstrated that the negative ions significantly facilitate learnings and reduce anxiety in rats. Other tests have shown that positive ions make rabbits aggressive, that given a choice mice markedly prefer negative ionised air, and that negative ions reduce the irritant effect of silica dust on guinea-pigs. Negative ion therapy has been successfully used in the Catholic University of Buenos Aires, Argentina in the treatment of large number of patients suffering from psychoneurosis and anxiety syndromes.

Ion imbalance has been incriminated as the sole factor responsible for the malaise produced in humans by ill winds as the Fohn in Germany and the Saharav in the Near East. The day before the hot, dry Near East Saharav begins, some people begin to suffer what the Israeli scientists call the 'irritation syndrome'. It is characterised by sleeplessness, irritability, tension, migraine, nausea, edema, palpitations, dyspnea, hot flushes, tremor, vertigo and diarrhoea. The elderly become depressed, apathetic and extremely fatigued. N. Robinson and F.S. Dirnfield measured solar radiation, temperature, humidity, wind and the electrical state of the atmosphere before, during and after the Saharav. They found that 10 to 12 hours before the onslaught of the wind and the humidity and temperature change, the total number of ions increased from $1500/cm^3$ to $2600/cm^3$ and the ratio of positive to negative ions jumped from 1.2 upto 1.33. The shift in ion ratio coincided with the onset of nervous and physical symptoms in the weather-sensitive. Danon, Weller and Sulman found that the victims of 'irritation syndrome' experienced relief when treated with negative ions, or with drugs that interfere with the production of the neurohumor, serotonin, chemically known as 5-hydroxy tryptamine (5-HT), in the body. Positive ions have been shown to raise, while negative ions to reduce, the 5-HT levels in the blood. Albert Krueger in the University of California, Berkeley has indicated that the brain 5-HT levels respond to air ion content of the atmosphere (*New Scientist*, Vol. 58, p. 668, 1973). It is not precisely established if 5-HT is the key substance mediating the ion effects of mood change. However, it is interesting that the 'irritation syndrome' mentioned above has been also called the 'serotonin-hyperfunction syndrome'. Since atmospheric ions are considered so important in the physical and psychological well being of man, it is not surprising that they received due attention of the space scientists. An enclosed compartment with 'air-conditioned' air, such as a space capsule, is likely to be depleted of ions, and probably to have a considerable excess of positive ions. Soviet scientists have suggested that ionisation in the capsule be increased to a more normal value of 2000 $ions/cm^3$.

Much of the research in Dr. Albert Krueger's laboratory in Berkeley, California, U.S.A. concerned with air ion effects in the respiratory tract of the animals. Positive ions markedly increased the death rate of mice infected with measured doses of a fungus (*Coccidoides immitis*), a bacterium (*Klebsiella pneumoniae*), or a strain of influenza virus. Ion-depleted air also increased the death rate in mouse influenza, while a high concentration of negative ions decreased the death rate. This may be related to the fact that positive ions produce the contracture of the smooth muscle in the air passages, while negative ions have the opposite effect. Thus, there is ample evidence to suggest that ion depletion increases the risk of respiratory infections.

It must be admitted that other health hazards of air ion depletion or positive air ion excess are yet to be recognised. In view of the wide range biological activities of air ions in germination of plant seeds, enhancement of plant growth and sporulation of fungus, etc., it will not be surprising if other ailments related to these atmospheric factors are discovered in future. Some day it may be felt worthwhile to 'air condition' the ions of our dwellings.

B. PAL

Energy transfer in ecological systems

THE single most essential requirement of all living things is energy. Energy is the ability to work. Without energy no work can be done and all life processes would stop. In any living thing cell enlargement, cell division, respiration, chemical reactions and all other processes require energy. If the environment is to influence an organism, it must do so by energy transfer between the organisms and the environment. The energy transformation in ecological systems can be easily understood by dealing with it (i) as ecological systems, and (ii) as energy transfer in the system.

Ecological system

We can consider the earth as a biosphere—a world of living organisms. The organisms inhabiting the biosphere interact and influence one another and they in turn are influenced by air, water, temperature, light and other physical conditions. So, an ecological system (ecosystem) is a sum total of living organisms, the environment and the processes of interaction between and within all parts of the system. A small pond can be taken as an example of the ecosystem. The pond ecosystem is a simplified ecosystem with small area of water and with less number of organisms; whereas when we consider an ocean as an ecosystem, it is a complicated ecosystem with vast area of water and with innumerable organisms living in it.

The boundaries of the ecosystems are largely determined by their physical characters and, in some instances, by the organisms composing them. The stability of the ecosystem is in direct relation with its size. Our ecosystem (the earth) consists of the producers (autotrophs: plants, some bacteria, and blue green algae) which provide the original source of organic matter; the consumers (heterotrophs) which obtain their energy by feeding upon other living organisms, and the decomposers (saprophagus) which obtain their energy by utilising dead and decaying organic matter. Now let us consider how the energy enters the system and what happens to it before it leaves the system.

Energy transfer

Each day, the earth is bathed by radiation (solar energy) from the sun. Of the total amount of solar radiation entering the atmosphere, roughly one-third is reflected back

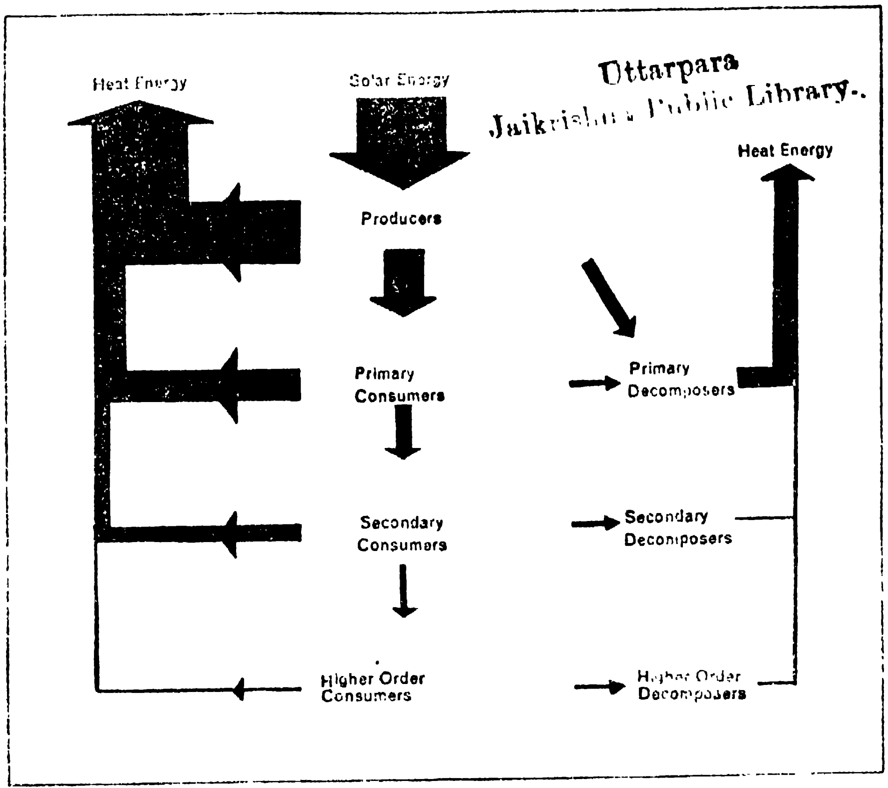

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Fig. 1. Diagrammatic representation of energy input and output in an ecological system

into space, one-third is absorbed by the particles floating in the atmosphere, and the remaining third is absorbed by the soil, water and organisms on the surface of the earth. All the activities on the earth are dependent on the absorbed energy.

Plants are the main producers in the ecosystem of biosphere. Only they have the capacity to convert the solar energy into chemical energy. The average amount of radiant energy per unit area per unit time actually available to plants varies with geographical locations. As much as 95% to 99% of the energy reaching the plants are immediately lost from the plants in the form of sensible heat and heat of evaporation. The remaining 1 to 5% is used in photosynthesis and is transferred to the chemical energy of plant tissues. This synthesis of plant materials by autotrophs is known as primary production and the total amount of chemical energy produced by them per unit area per unit time is referred to as the gross primary production. Now the energy has entered and become fixed in the system.

All the energy synthesized are not available to the heterotrophs. A part of the synthesized energy is broken down (oxidation) to meet the energy requirements of the plants to perform work (synthesis of organic matter) in the process of respiration. So the food energy potentially available to the heterotrophs is gross primary production minus respiration. This energy is called net primary production. In nature, net primary production is normally between 80 to 90% of gross production.

The solar energy transformed into chemical energy is thereafter transferred to the next level of the ecosystem, the consumers, referred to as heterotrophs. The primary consumer is a herbivore (i.e., plant-eating). Of the total energy consumed by the herbivore, a part is assimilated and the rest is lost in the form of faces. A part of the assimilated energy is spent for their metabolism (respiration) and the remaining energy is made available for the next step of transformation. This energy is designated as net secondary production. In general, rate and efficiency of energy transformation in herbivores is 20 to 70%. The next stage of consumers are the carnivores (i.e., flesh-eating). The net energy from the primary consumers are passed on to the carnivores, and here also, the energy undergoes the usual pathway of transformation. The net energy at each level will be passed on to the next carnivore (e.g., Carnivore$_1$ ⟶ Carnivore$_2$ ⟶ Carnivore$_n$, etc.). But the rate and efficiency of energy transformation by the carnivore is greater than that of the herbivore (70 to 90%). At one stage of the system, the energy entering the system will be just equal to the energy going out of the system in the form of heat and dead organic matter, i.e., no energy will be transformed to the next level. At that stage, the total energy entering the system will be equal to total energy output from the system.

At each level of the system (producer, consumer, etc.), some energy is transformed into the decomposers as dead and living organic matter. The decomposers also follow the same pathway of energy transformations and here also, at one stage, the energy input will be equal to the energy output from the system. So the total solar energy input into the ecological system is returned to the solar system as heat energy at each stage of transformation without creation or loss but with a degradation of energy from one form to another which confirms the laws of thermodynamics.

S. Mathavan

Organic wastes can be converted into oil

THE present day crisis created by the oil producing countries has changed the economic, social, political and even cultural outlook of the advanced countries. The situation is far more worse in the developing nations. Oil plays a very significant role in the lives of human beings and it is a very convenient form of fuel. Because of these reasons, attention is being diverted to develop science and technology to meet this challenge. Petroleum, being available in limited quantities, have to be replaced by other means. Initial attempts have been made to convert coal into oil. This has been achieved by using hydrogen at high pressures and temperatures in the presence of a catalyst. In order to avoid the use of hydrogen in the production of liquid fuels the work has been carried out at the Pittsburg Energy Research Centre of the U.S. Bureau of Mines. The low grade coal when treated with carbon monoxide and water at high pressure and temperature was converted into low sulphur benzene-soluble oil. At the same time the reaction of coal with carbon monoxide and water was found to be faster as compared to that of coal with hydrogen. The success of this process demanded further exploratory work where different compounds having same structure as carbohydrates were tried out. The base material varied from sucrose, animal waste (which is mostly cellulosic), glucose, corn stalk, newspapers and even urban waste have been converted into oil. The process has been developed where any waste material which is largely carbohydrate or contains some carbohydrate type of structure can be converted into oil.

Assuming that about half of the energy content of the organic waste will be needed to run the waste-to-oil conversion process, still the oil production will be sufficient to meet the growing demands of the nation.

Chemistry of conversion process

The cellulose when heated to 250 to 400 °C loses water, carbon dioxide and carbon monoxide and forms a solid black material called char. The char is also formed when cellulose is heated with hydrogen to these temperatures. The addition of water has no effect but carbon monoxide and water converts into oil. The oil yields were further increased when sodium carbonate was used as a catalyst.

The carbon monoxide and waste material react in the presence of sodium carbonate to form hydrogen and carbon dioxide in a water-gas shift reaction. It was presumed that hydrogen thus produced adds to cellulose during its conversion to oil. However, when hydrogen was added to the reactor no effect was noticed. The addition of carbon monoxide was more effective. The carbon monoxide reacts with sodium carbonate to form sodium formate (HCOONa) is the potent reducing agent for the reactive intermediates formed by the heating of carbohydrates. The formate probably reacts directly to convert carbohydrate to oil.

The sodium formate is converted back to sodium carbonate upon reduction of the carbohydrates. This reacts with carbon monoxide to form the formate in a cyclic fashion. It is therefore not necessary to use more than catalytic quantities of sodium carbonate in the reactor.

$$\mathrm{Na_2CO_3 + H_2O + 2CO \rightarrow 2HCOONa + CO_2}$$
$$\underline{\mathrm{2HCOONa \rightarrow H_2 + CO + Na_2CO_3}}$$
$$\mathrm{H_2O + CO \rightarrow H_2 + CO_2}$$

The complete water-gas-shift reaction in which elemental hydrogen is formed is, therefore, believed to be an unwanted side reaction which cannot be entirely avoided but should be minimized to reduce the consumption of carbon monoxide. Using lowest temperature and pressure still consistent with liquefaction may reduce the shift reaction. The carbon monoxide and hydrogen gases make up synthesis gas, the cheaper synthesis gas can be used directly in the process instead of adding pure carbon monoxide. The carbohydrates under the influence of high temperature and alkaline environments undergo many reactions. These include reduction, isomerization, disproportionation, decarboxylation and various combinations of these before oil is formed.

Animal manure which is largely cellulosic, but it is more resistant to conversion than cellulose itself, however high temperature of 380 °C and high pressure (400 kg/cm^2) and treatment with carbon monoxide have converted the animal waste into oil. The manure contains calcium sodium and potassium, therefore the addition of catalyst was found to be not necessary. The oil yield depended upon the carbohydrate and lignin content of the manure.

Methods of processing

The animal or organic solid waste can be converted into oil by two processes, e.g., batch process and continuous process. In the batch processes the material is heated to a high temperature of 380 °C and the carbon monoxide and water are then added into the chamber at

Table 1. Composition of bovine waste and oil

Constituent	*Composition of manure per cent*		*Composition of oil per cent*
	As used	*Dry, ash-free basis*	
Carbon	20.5	52.2	78.6
Hydrogen	2.5	6.4	9.5
Nitrogen	1.3	3.3	4.2
Sulphur	0.5	1.2	0.37
Oxygen	14.5	36.7	7.3
Ash	15.1	—	—
Water	45.5	—	—

the desired pressure of 360-430 kg/cm^2 and is hold for about 20 minutes. In continuous process the material is to be fed in the form of slurry into the reactor at high temperature of 500 °C and pressure of about 360 kg/cm^2 into which carbon monoxide is pumped. The material is injected into the bottom of the reactor. The liquids and gases exit at the top of reactor and separate in the high pressure recovery system. The liquid is collected intermittently into secondary receivers at atmospheric pressure and the gas is released through a back pressure regulator. The reaction time is approximately 20 minutes. Fig. 1 gives the line diagram of the continuous process.

The preliminary experiments have shown that using sucrose as a base material the oil recovery was 38% whereas theoretical maximum expected is 50%. In case of urban waste the recovery was 24%. The oil thus produced has the composition as shown in Table 1. It has a heating value of 18,000 CHU/kg. The oil produced is mostly aliphatic with ether linkage and carbonyl and hydroxyl groups present. The material appears to have cyclic structure.

There is a great potential in the process. A significant part of the nation's oil requirements can be met from the development of this technology. Before this can be made a commercially feasible process, it would be essential to acertain the engineering data and nature of reaction so that the reaction may be carried out at low pressure and at lower temperature. The methods of reducing the consumption of carbon monoxide have to be determined. The reactor design to improve the gas-liquid contact area so as to accelerate the reaction has to be determined.

These will be essential so as to find the optimum conditions for the

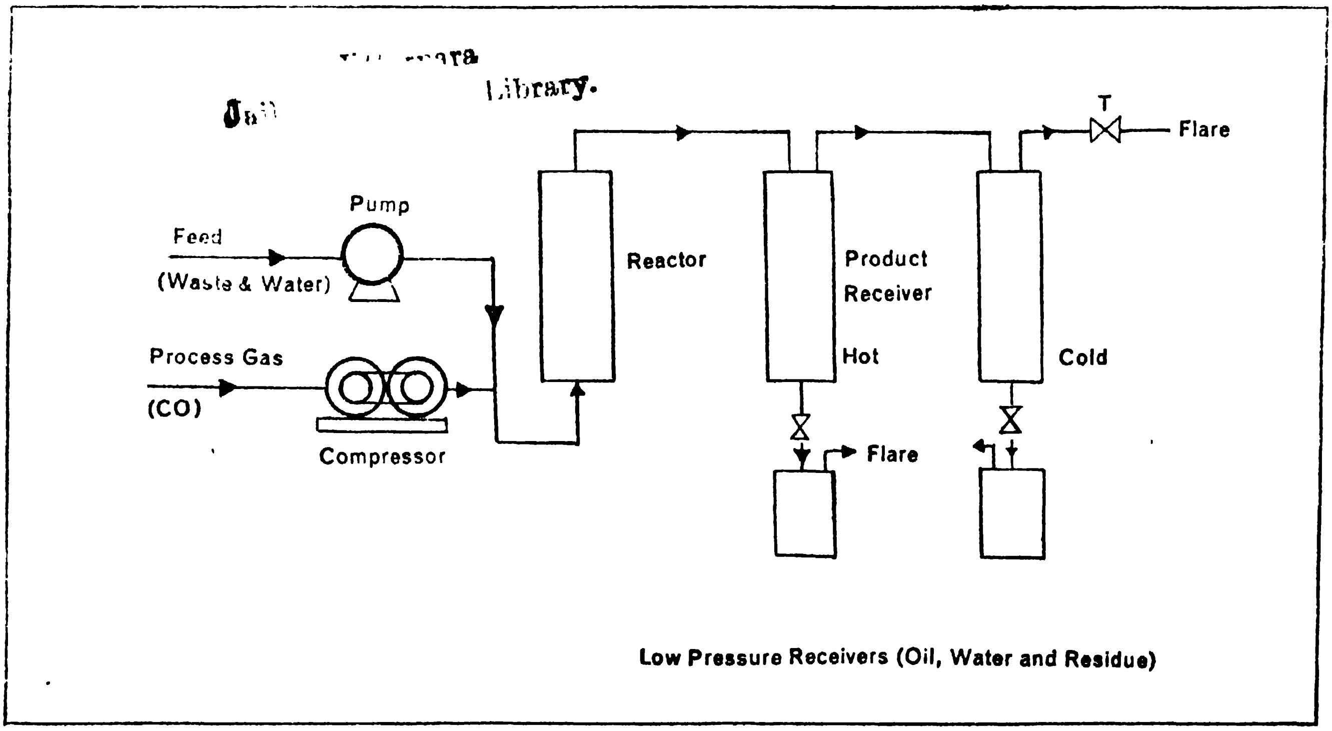


Fig. 1. Schematic diagram of continuous process for converting organic waste in to oil

oil production. The problem is not simple and it is right time for the scientists and technologists to take up this challenging problem. Thus in future beside producing oil from the urban waste, the country would have cleaner cities.

R.S. DEVNANI

Acoustically sound auditoria

AN uncontrolled sound is called noise, but it is well within man's power to control it. The science of acoustics deals with production, transmission and absorption of sound in buildings. It also includes sound control and dissipation of external noise.

Sound is transmitted in the form of spherical waves which are a series of compressions and rarefactions created in the medium through which it travels. At normal temperature and pressure sound travels with a velocity of 340 meters per second. The frequency of sound is defined as the number of vibrations per second. The highest audible pitch is 20,000 cycles per second and the lowest 20 cycles per second.

Table 1. Velocity of propagation of sound in various media

Medium	*Velocity of propagation (m/sec)*
Air	340
Water	1420
Brick	3000
Concrete	3400
Glass	4100
Aluminium	5100
Steel	5200

When sound is produced either as a speech or music it is transmitted from the source in all directions. The sound waves impinge on a surface. From there, they are partly reflected, partly absorbed and partly transmitted to other sides. The amount of reflection, absorption and transmission depends upon the character of walls and all surfaces. For instance, a hard and smooth wall reflects most of the sound. So, only a little amount is transmitted and absorbed, whereas a porous wall absorbs most of it. The reflection of sound possesses certain acoustic virtues such as enrichment of tonal quality and loudness if properly controlled, otherwise it results in acoustic defects such as echoes and dead spots.

An echo is produced when a reflected sound originating from the same source reaches the ear when it has already heard a direct sound. Hence, it is a repetition. Echo occurs when the time lag between the direct sound and the reflected one is 1/15th of a second or more. In case the time lag is shorter, it reinforces the original sound making it very clear and audible.

Excessive concentration of sound at some places necessarily results in comparative deficiency at others. Positions in a room which are far from reflecting surfaces with the sound arriving only after grazing over an audience for some distance, are likely to constitute dead spots.

Reflected sound waves, before they are reduced to one millionth of their original intensity, continue to travel and get reflected a number of times even after stoppage of the source. This phenomenon is known as reverberation. The period of reverberation depends directly on the dimensions of a room and inversely on the total absorption provided by it (Fig. 1) (absorption = surface area × it's absorption coefficient). Auditoria are generally designed keeping in view the purpose for which they are intended (speech, music, motion pictures, etc.). Table 2 gives reverberation times for different auditoria.

Table 2

Auditorium used for	*Acceptable reverberation time (seconds)*
Speech.	1 to 1.5
Music	2 to 2.5
Music + speech	1.5 to 2
Cinema	0.6 to 1.2

The important acoustical considerations in designing an auditorium are: (i) volume, (ii) shape, (iii) sound-reflection, and (iv) absorption by surfaces. Volume of a hall should be decided in accordance with the intensity of sound that is going to be generated. The spaces required for an individual in a public lecture hall, concert hall and a motion pictures theatre are 2.8 to 3.7 cubic

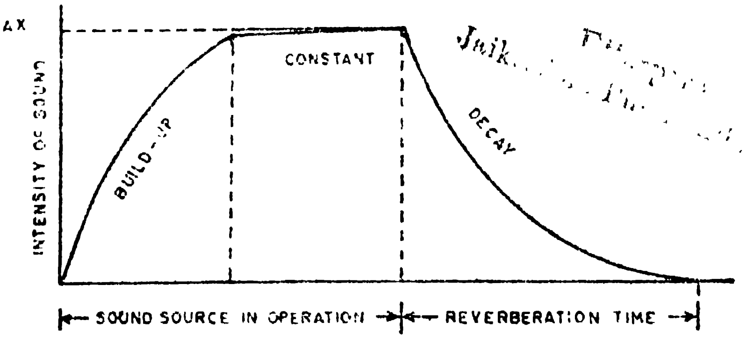


Fig. 1. Propagation of sound

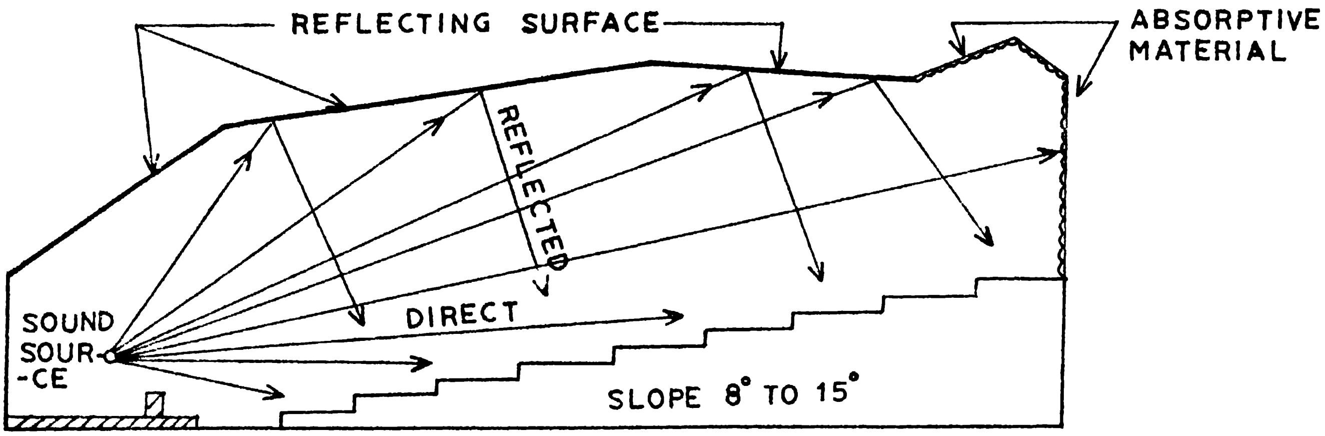


Fig. 2. Racked floor auditorium showing direct and reflected sounds

metre, 4.2 to 5.6 cubic metre and 3.7 to 4.2 cubic metre respectively.

In designing an auditorium it is always necessary to elevate and stagger the seating arrangement (Figs. 2 and 3). The angle of elevation should be between 8 to 15° for clear visibility and good audibility. The audience at the back side, generally, does not get direct sound to hear. Reflectors should therefore be used at proper places on ceiling as well as on side-walls. Care should be taken that the reflection of original sound reaches the listeners within 45 milliseconds after the direct sound is heard, as any sound heard after that will be an echo. Among the floor plans, fan shape and rectangular shapes are considered better than oval and circular shapes as they give rise to acoustical defects such as dead spots and concentration of sound in auditoria. In case of rectangular shapes, the length should be twice the width and the ceiling height 2/3 of the width. As far as possible, rear walls should not be given concave shape unless treated with sound absorbents as they concentrate sound at one spot only.

Ceilings of auditoria play an important role in reflecting sound to rear areas of the hall. Hard and smooth reflectors having the slope away from the speaker or source of sound are required. As the concave surface tries to concentrate sound at one spot only, the roof in the shape of dome should be avoided. When the ceiling is not of correct shape, i.e., flat or horizontal, false ceiling with the aid of suspended reflectors can be provided. Parts of ceiling at the rear may be treated with absorptive material.

In large auditoria a balcony is essential, or else the hall would be too long. The balcony overhead should not be more than double the free height of the balcony. Sound-absorbing materials are indispensable for any acoustical treatment to provide proper sound insulation in auditoria. Some of the well-known sound absorbents are:

(a) *Acoustillite.* This is made of compressed would pulp or wood fibres and is also available

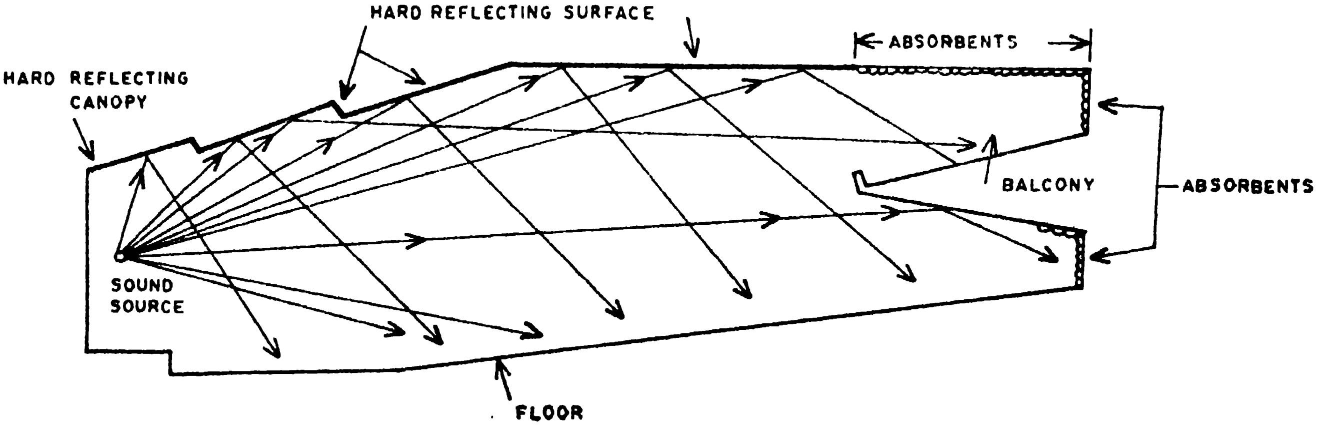


Fig. 3. Longitudinal section of an auditorium

in the form of tiles (absorption coefficient = 0.57).

(b) *Acoustical blanket.* Prepared out of mineral wool or glass fibres (absorption coefficient = 0.57).

(c) *Hair felt.* Consists of wool fibres, coarse cotton fibres, etc. (absorption coefficient = 0.58).

(d) *Fibre-glass* (absorption coefficient = 0.8).

(e) *Cork carpet:* For covering floors and prepared out of pieces of corks treated with linseed oil (absorption coefficient = 0.4).

(f) *Acoustic plaster.* Mainly consisting of gypsum in the form of plaster (absorption coefficient = 0.42).

The above mentioned absorbents are good in service, but the choice of a suitable absorbent, however, depends upon the requirement of the job and economy.

To achieve proper sound insulation in an auditorium the type of construction also plays an important role. For instance, non-porous and rigid construction such as solid brick masonry provides good sound insulation. A double wall construction with intervening air space is much more effective than a single rigid wall.

V.B. RAMAPASAD

Fluorinated hydrocarbons as a substitute for blood

BLOOD is a liquid tissue of our body. Its main function is to transport dissolved materials from one part of the body to the other. Transportation of simple food materials, waste products of various tissues, different secretions like hormones, enzymes, antibodies and others, gases like oxygen, carbon dioxide, etc., takes place through blood. Importance of blood cannot be overestimated. Without its flow in our body, we will cease to live. Erythrocytes which are red blood corpuscles transport oxygen and carbon dioxide. Blood carries oxygen from air to the individual cells and carries carbon dioxide back from cells and expels it from the body through lungs. In many serious diseases and major operations, blood transfusion becomes necessary to save life. Natural blood transfusion is bothersome and it is expensive to collect, store and administer blood. It requires type identification and cross-matching. Sometimes suitable blood is not available and there is danger of infection. So it was thought worthwhile to search for a substitute which may work as efficiently as natural blood. Various haemoglobin preparations have been tried as a substitute for blood, but without much success.

Recent researches have, however, opened up a new line to tackle the problem. Some chemicals have been discovered which can execute certain functions of the blood as efficiently as the natural one. They promise to be substitutes for blood. This new and epochmaking possibility came up from the work of a Harvard University professor. He removed the entire blood from the body of a mouse and replaced it with a group of organic liquids which could function like erythrocytes. It was surprisingly found that the mouse could survive long enough for natural blood to regenerate. These organic liquids are nothing but flourinated hydrocarbons or more popularly known as fluorocarbons.

Fluorocarbons are a group of hydrocarbons having hydrogen atoms replaced by fluorine. Chemically and biologically they are stable compounds. They are clear liquids of high mobility and low surface tension. Fluorocarbons were discovered during the Second World War for separating isotopes of uranium needed for atomic bomb. Flourocarbons possess a peculiar property which is that they can absorb 15 times more oxygen and carbon dioxide than blood and hence can perform one of the most vital functions of the blood, that is transport of the gas. Oxygen-carrying properties of fluorocarbons was not known until 1960, when Dr. Leland Clark of the Medical School, Cincinnati University and Dr. Frank Golan of the Miami University Medical College, U.S.A. observed that mice immersed in oxygenated fluorocarbons for an hour survived without facing immediate death. The animal could obtain enough oxygen for its body requirement from this liquid. This experiment suggested that fluorocarbons are both oxygen carriers and nontoxic.

The breakthrough in the possible use of this magical fluid as a substitute for blood came in 1972, when Dr. William Rosenblaum of the University of Virginia Medical College announced in the American Heart Association Conference in Dallas that after replacing 75% of blood of a mouse with fluorocarbons, there was no electrical or biochemical brain abnormalities. Though fluorocarbons disappeared from blood after sometime, some remained behind in certain organs of the body like liver. There was a possibility that their long term toxicity may harm the animal. Nonetheless their use in animals holds a promise. In an acute case, where the animal is facing immediate death due to nonavailability of suitable blood, fluorocarbons can be used and life saved for some more months. There is also a possibility that the fear of long term toxicity of fluorocarbons may be removed by proper selection of fluorocarbons. They may not be kept behind in certain organs and hence may not be able to cause long term toxicity as feared.

Dr. Robert Geyer of Harvard School of Public Health has used some types of fluorocarbons as a substitute for blood with considerable success. He used rats as his experimental animals. They breathed highly oxygenated air and lived even after total blood replacement by fluorocarbons. They also retained their capacity to regenerate new blood including cells, proteins and hormones. Some of these rats were still alive after six or seven months of transfusion. Dr. Geyer examined nearly 1200 different preparations of fluorocarbons and has found one with a good balance of flow characteristics and oxygen carrying capacity. This balance could support life. Dr. Geyer has carried out an experiment with dogs and is confident that fluorocarbons transport gas without harming the animal.

Instead of totally replacing blood by fluorocarbons, Dr. Clark mixed dog's blood with fluorocarbons and reported that the dog had lived more than four years after flourocarbon transfusion without any sign of deterioration. Though these animals retain fluorocarbons in their livers, they look and work like healthy animals without showing any sign of toxicity. New fluorocarbon preparations are being tested to find if some can be developed which would not be retained by the body organs like earlier fluorocarbons. The Cincinnati group has been able to develop some, after examining nearly 100 different preparations whose retention property by the body organ is negligible. Clark calls this a major breakthrough and is of opinion that days are not very far off when human beings may be able to walk around with fluorocarbons in their veins and arteries instead of blood.

GOKULANANDA MAHAPATRA

How much copper does your body need ?

IF we proceed to decide on the utility of a substance by the amount in which it is taken into the body, we will grossly underestimate certain substances which are required only in trace amounts and yet are essential to many vital functions. Prominent among them are the vitamins and the minerals. While most of us are familiar with the vitamins and the important role they play in general metabolism, many of us are not aware that the minerals too can be equally vital in the maintenance of life.

Our body requires seven minerals in the main: calcium, magnesium, sodium, potassium, phosphorus, sulfur and chlorine. Seven other elements are required in trace amounts: iron, copper, iodine, manganese, cobalt, zinc and molybdenum. Several other elements are present in tissues but with unknown function. Together the minerals constitute a negligible fraction of the bodyweight and yet they are involved in such diverse functions that it would be impossible to imagine of any animal life in the absence of even one of them.

Concentration of copper

Copper is found only to the extent of 100-150 mg in the whole of the human body. Although it is distributed throughout, certain organs have consistently higher copper concentrations than others. Liver, brain, heart and kidney contain the highest amounts. Moderate amounts are found in lung, intestine and spleen. Endocrine glands, muscle and bone have the lowest copper concentrations. Muscle and bone, however, because of their mass contain approximately 50% of the total body copper.

Absorption. The site of copper absorption is limited mainly to the stomach and small intestine in most mammals including man. Mechanisms of copper absorption are little understood. At present, however, it is believed that as the ingested food passes through the gastro-intestinal tract, copper is released either as ionic copper or as a copper-amino acid complex. A fraction of the ionic copper combines with the available amino acids in the lumen to form a copper-amino acid complex and is then either actively transported or diffused into the circulatory system. Rest of the ionic copper is transported in loose association with some copper-binding proteins as metallothionin.

Chemically similar elements as cadmium, mercury, silver and zinc interfere with copper absorption by competing for binding sites in the copper-binding proteins resulting in copper deficiency.

Transport. The major portion of the absorbed copper in the plasma is divided into four fractions, *viz*., erythrocyte fraction, plasma albumin fraction, plasma ceruloplasmin fraction and plasma amino acid fraction for transport to various issues via the liver. The erythrocyte fraction, however, is not involved since the erythrocytes themselves require a constant amount of copper.

Function of copper

Within the cells and in the fluids bathing them, copper forms complexes with organic molecules and is found associated with amino acids, nucleotides, DNA, RNA and proteins. Several proteins require copper as a part of their molecular structure.

Ceruloplasmin is a dark blue protein in the blood plasma with a molecular weight of 160,000 daltons containing about 8 copper atoms per molecule. Ceruloplasmin is involved in the metabolism of a number of hormones such as epinephrine, nor-epinephrine, serotonin and melanin. Recent experiments also indicate that ceruloplasmin is essential to hematopoiesis. Haemoglobin is the red colouring matter in the blood to which the oxygen carrying capacity of the blood is related. For normal haemoglobin synthesis iron must be mobilized from storage depots in the intestine, liver and reticuloendothelial system to bone marrow cells which are the sites of haemopoiesis. Ceruloplasmin is known to affect this transfer. Also it brings about the oxidation of ferrous iron, in which form The latter is found in the storage cells, to ferric iron in which state it is utilized in the synthesis of haemoglobin.

Cytochrome oxidase is the terminal enzyme in the electron transport system of mitochondria which is involved in the cellular respiration for the release of energy. Cytochrome oxidase requires copper for its catalytic activity.

Collagen is a protein, most widely distributed in the body whose main function is to maintain the structural integrity of the tissues and organs. Once it is synthesized in the tissues its stabilization is essential for its function. One variety of monoamines is responsible for providing precursors that bring about the stabilization, mediated by an enzyme, monoamine oxidase. And monoamine oxidase owes its catalytic activity to copper, since copper deficiency is characterised by poor formation and fragility of the bones that result from the impaired cross-linking of collagen.

Tyrosinase, the enzyme responsible for the synthesis of melanin, requires copper. Absence of tyrosinase results in albinism, a diseased state in which the skin and hair fail to develop the normal colour.

Super oxide dismutase is another copper-requiring enzyme, which by catalysing the dismutation of super oxide free radical anions released during the oxidation of xanthine, a kind of nitrogenous base, protects the cells from the damaging effects of a toxic substance like the super oxide anions.

These are only a few of the copper-containing enzymes in the body. Others include lactase, ascorbic acid oxidase, urease, dopamine-hydroxylase, aminolevulonic acid dehydrase and galactose oxidase which perform equally important functions in the body.

The human requirement of copper has been fixed at about 2.5 mg per day, which is supplied by our average diet. Infants and expectant mothers require copper in higher concentrations. Because of its ubiquity, copper deficiency is rare, but then there are certain parts of the world where copper deficiency is endemic. Although copper is essential to many a vital function, an excess can be equally toxic. Acute copper poisoning results in intestinal ulcer, hepatic cell death, nausea, vomiting, diarrhoea, haemoglobinuria and jaundice. A genetic abnormality which also leads to toxic accumulation is Wilson's disease. It is due to the production of an abnormal protein with an increased affinity for copper which alters the normal copper homeostasis in the liver (*S. R.* April, 1972 p. 191).

Another genetic abnormality of copper metabolism is manifested in Menke's Kinky Hair Syndrome, a deficiency state characterized by slow growth and progressive-cerebral degeneration leading to early death. Prolonged oral administration of copper has little effect, since the primary defect is one of its intestinal absorption whose cause has not yet been found out.

The extremes of copper deficiency and its toxicity mean that the mineral be properly and efficiently metabolised in the body to ensure that sufficient copper is made available and toxic accumulations are prevented.

Several elaborate mechanisms are involved which make sure that any excess copper than necessary is excreted via the bile which is the major pathway of its excretion. Several hormones such as the pituitary, adrenal, thyroid and sex hormones are actively involved in its regulation. Liver by acting as the storage depot plays the central role. The liver prepares the excess copper for excretion in the bile and by synthesizing ceruloplasmin incorporates it.

SURESH CHANDRA PADHI

Hypophysation—an answer to the problem of pure fish seed

THE Indian major carps and many other freshwater fishes do not breed in confined waters of ponds. Therefore, fish seeds are collected from rivers and are then transported to different ponds. This is an expensive as well as an over arduous practice. Moreover the seeds of major carps get contaminated with that of carnivorous fishes; and when hatched, the youngs of carnivorous fishes take a heavy toll of that of major carps. The only dependable solution is to practice the technique of hypophysation, which is easy, less expensive and gives pure seeds.

Hypophysation is a technique by which an individual is induced to breed by hypophysis (pituitary) extract. B.A. Houssay (1930) of Argentina was first to use pituitary extract of a fish, *Prochilodus platensis*, to induce breeding in another fish, *Cresterodon decemmaculatus*. But Brazilians were the pioneers to develop the technique in 1934. Since then, the technique has spread gradually (USSR-1937, USA-1940, Red China - 1954, India - 1955 and Japan-1965).

Collection of pituitary gland

The gland is collected preferably from living or freshly killed fully matured fish. Such a fish is known as a *donor*, whereas the fish which is to be induced to breed is called a *recipient*. A donor, which is preserved either in ice or cold storage also contains a potent pituitary. Glands collected from fish prior to spawning, immediately after spawning and also from unripe fish show relatively low potency. A rotten donor is worthless. Generally the species of the donor does not vary from that of the recipient.

The gland is collected by removing the brain either from dorsal side or through the *foramen magnum*. The gland is also collected by removing the sphenoid bone (the bone of the floor of the brain-box). Every possible precaution is taken to collect the gland entire as a damaged one looses its potency.

Preservation of the gland

The glands are preserved either in (i) absolute alcohol or (ii) chilled acetone, (iii) immediately freezed or (iv) dried at room temperature after treating with cold acetone for 36-48 hours.

Preparation of pituitary extract

There exists a more or less fixed ratio between weight of the recipient fish and the quantity of pituitary gland required for hypophysation. Therefore, the exact quantity of the gland needed is taken in a tissue homogenizer (Fig. 1) with a little quantity of (i) distilled water or (ii) physiological saline solution or (iii) 0.3% NaCl solution or (iv) a mixture of 0.6-0.7% NaCl and glycerine (7:3 v/v). This is then properly macerated and centrifuged. The clear supernatant fluid is the pituitary extract. The extract is also prepared in 1.5% TCA (Trichloroacetic acid); but then, the glands are not macerated but kept intact in the TCA, which extracts the effective gonadotropins from the gland.

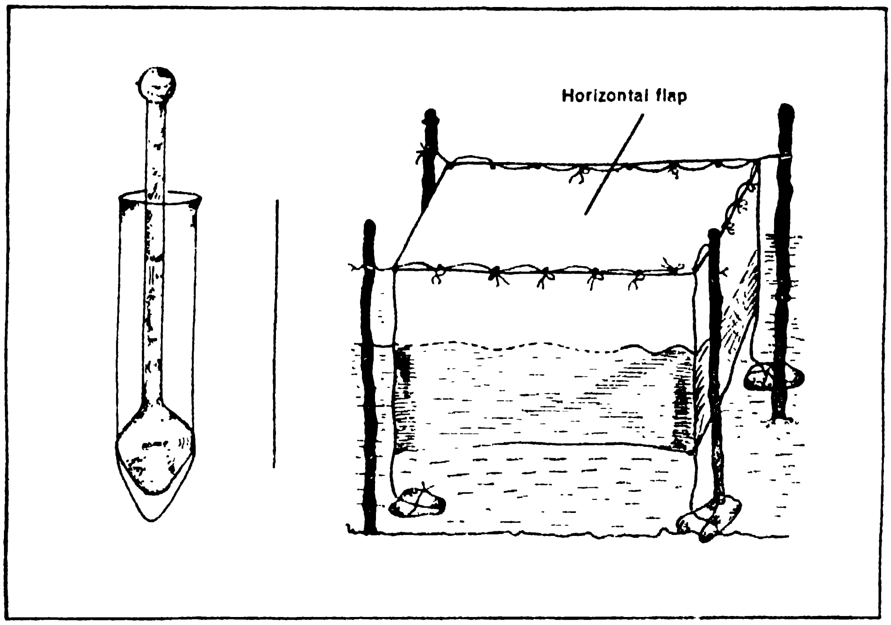


Fig. 1. A tissue homogenizer (left) and a breeding *hapa* (right)

Sometimes it becomes impossible to prepare the extract on the spot. Therefore, preparation of the extract well in advance becomes necessary. For this, the extract is prepared in distilled water and is kept with glycerine in an air tight container for 3-4 days. When all sediments settle down, the supernatant liquid is taken and ampouled. These ampoules can safely be distributed to fish culturists in remote areas.

Long before hypophysation, adequate number of healthy recipients in the age group of 2-3 years with weights ranging from 2-3 kg are stocked sexwise in two tanks (*segregation tank* or *brood fish ponds*) with moderate depths at the rate of 1000-2000 kg/hectare.

Method of injection

Hypophysation operation starts with the advent of monsoon. Males with oozing milt and females with soft, bulging abdomen with swollen pinkish vent are selected for the operation. Pituitary extract is injected into the recipients either (i) intramuscularly or (ii) intraperitoneally or (iii) intracranially. In the first method, which is usually

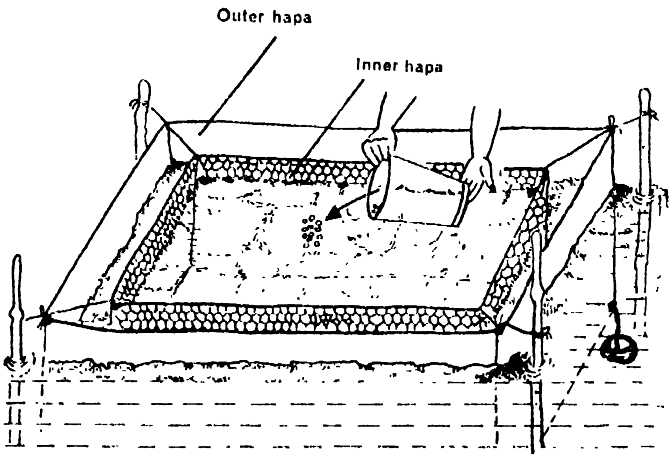


Fig. 2. Hatching *hapa* showing method of release of fertilized eggs

followed, injections are made between scales of caudal peduncle or near the shoulder region, but never near or on the lateral line. Sometimes penicillin is added to the extract, which protects recipients from post-injection inflammations and infections. Normally injections are administered in the evening.

Post-injection operation

The injected males and females are kept in a *breeding hapa* (Fig. 1) erected in a pond. A breeding hapa is an inverted mosquito net-like structure made of non-meshed cloth. Usually its open top remains covered by another rectangular cloth to prevent jumping out of breeders. A breeding hapa generally contains two males and one female. Spawning takes place within 6-9 hours. If breeders fail to breed but their condition remains encouraging, each of them receives a second injection. Spawning commences within the next 3-6 hours. When embryo starts twitching movement within the egg, eggs are transferred to *hatching hapa* (Fig. 2) erected in a pond with clear water and mild wave. A hatching hapa consists of two hapas—one fitted inside the other. The outer hapa is made of non-meshed cloth whereas the inner hapa is made of fine meshed cloth. After hatching, the hatchlings move out through the holes of the inner hapa into the outer hapa. The inner hapa is, then, removed with unfertilized eggs and egg cases left inside it.

Apart from providing pure fish seeds, hypophysation is also helpful in hybridizing fishes. In India it has already helped to establish several interspecific hybrids (e.g., hybrids of *Labeo rohita* and *L. hycalbasu*, etc.) and intergeneric hybrids (e.g., hybrids of *Catla* and *Labeo*, *Cirrhina* and *Catla*, etc.).

R.R. SEN ROY

Viscosity bridge

IT is well known that hydrodynamics and current electricity have much in common and this experiment illustrates it with reference to the principle of the Wheatstone's bridge. The four arms of the Wheatstone's bridge have been replaced with four capillary flow elements with a small liquid pellet along a diagonal tube to take the place of the galvanometer and a small blow ball at one of the remaining pair of junctions to apply, in replacement of the battery, the excess pressure over atmosphere to which the other junction is open. The actual arrangement and its electrical equivalents circuit are indicated in Figs. 1 and 2. Arms *A* and *B* of the bridge are identical bits of fine capillary tubes containing only air while *C* of known length and girth also containing air is made to match with the fourth limb *D* which is of wider cross-section and contains a long pellet of any liquid. The experiment consists in adjusting the length of the liquid column by gradual removal with filter paper or by feeding in the liquid through a side tube (not shown in Fig. 2), until there is no movement of the indicating pellet *G* when the blow ball is slowly operated. With clean tubes the balancing position is critical and the required length of the liquid

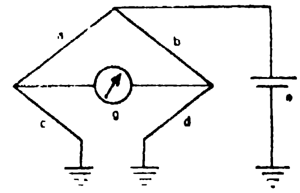


Fig. 1. Wheatstone bridge

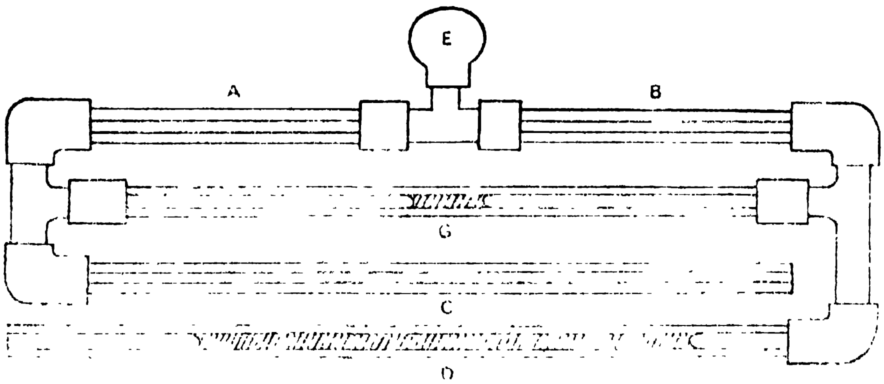


Fig. 2. Viscosity bridge

column can easily be estimated with an accuracy of about 2%. The viscosity of the liquid is then calculated in terms of that of air or vice versa. Other proportions between the ratio arms are obviously possible and the method can easily be extended to any liquid and possibly to other gases.

If under condition of balance the blow ball is operated quick, the equilibrium is appparently violated which only extends the analogy to A.C. bridges. When the difference in applied pressure varies rapidly the inertia of the pellets of liquid and the compressibility of the enclosed columns of gas function in a way identical respectively with inductance and capacity in an ordinary A.C. bridge.

The viscous analogue of Wheatstone bridge is not only convenient for easy comparison of viscosities but can vividly demonstrate what happens along a particular arm of any type of a network built with capillary counterparts, since under steady conditions viscous flow and electric current bridges are essentially governed by Kirchoff's laws of networks.

A.O. Mathai

Gamma rays for food preservation

EVERYBODY is well aware of the deadly properties of gamma rays. But this lethal ray can be used effectively in the service of man by way of preserving food for a long period. Now-a-days, uncooked, partially cooked or even fully cooked foodstuff is usually preserved by refrigeration. This process however cannot keep the food unspoilt for a long period as it cannot completely destroy the organisms which decay the food. Organisms in the refrigerated food remain in the dormant form and on getting a chance begin harmful activities. It was found that even at the temperature of liquid air, that is, –192° C, many organisms responsible for food decay survive. Refrigeration is therefore not an effective method of preserving food for a long period. On the contrary if foodstuff is irradiated by gamma rays, the harmful organisms responsible for food decay are totally destroyed and the former can be preserved for longer periods.

Now it is a question whether the food irradiated with gamma rays is safe to eat or not. There is no evidence that the food matter after irradiation shows any trace of radioactivity. Irradiated foods are now being fed regularly to generations of animals in order to detect any harmful effects on their normal growth.

Gamma radiation has no bad effect either on the taste or flavour of the food matter. Cooked or raw carrots, cooked peas and beans, cooked spaghetti or macaroni, spinach and cooked potatoes have been preserved by gamma radiation and none of them have changed appreciably in taste and flavour. Milk, however, develops an unpleasant taste after irradiation.

Food preservation by gamma rays may seem to be an expensive process, but it is not so. Large amounts of radioactive wastes result from production of atomic fuels like plutonium and others in nuclear reactors. As these wastes are radioactive in nature they cannot be disposed of like ordinary industrial wastes for danger of contamination. At present, radioactive wastes are being dumped in deep underground tanks designed to hold these wastes for five hundred years. As the number of nuclear reactors are increasing day by day for their peaceful uses, the quantity of radioactive wastes is also increasing. It has become now a problem to dump radioactive wastes in expensive underground tanks. If, however, these wastes are used to preserve food by utilizing their gamma radiation, two problems can be solved simultaneously. First, large quantities of radioactive wastes will find commercial use and their disposal expenses may be reduced drastically. Secondly, a large amount of food matter may be preserved for future use at a small cost.

Gokulanand Mahapatra

NEWS & NOTES

The third meeting of ASCA

IN recent years there has been a growing awareness among the countries of South East Asia that imported technology from the West did not serve the best interests and needs of their people, and that there was need for active cooperation among themselves to identify areas of mutual interest in the field of science and technology and to devise means for providing solutions to their common problems. The third meeting of the Association for Science Cooperation in Asia (ASCA) which was held in New Delhi from 8-10 April, 1974 provided an opportunity for the participating countries to exchange views and work out plans for such cooperation. Over 40 delegates from 13 countries of South East Asia and the Oceania participated in the three-day meeting.

ASCA had its beginning in 1970 when the Government of Philippines invited a number of South East Asian countries for setting up an Association of Ministers of Science in Asia (AMSA) to "serve as a regional instrument for the effective application of science and technology to the consideration of plans and strategies for the maximum development of the vast human and material resources in the region and thus enable each member State to achieve full economic growth consistent with the aspirations of its people." The preparatory meeting held in Manila, however, decided that instead of AMSA, regional cooperation through an "Association of Science Cooperation in Asia (ASCA) should be established."

India did not participate in the first formal meeting of ASCA held in Manila in 1972. The second meeting was held in Tokyo in 1973 and was attended by an Indian delegation led by Prof. Y. Nayudamma, Director-General, CSIR. It was at this meeting that a decision was taken to hold the third meeting in New Delhi.

Inaugurating the third meeting of ASCA in New Delhi's Vigyan Bhavan on 8 April, the Minister for Science and Technology Shri C. Subramanian stressed the need to promote awareness, at the highest level in planning and excution in the Governments of the participating countries, of the crucial role that science and technology can play in accelerating economic development. "In view of the fact that many of the economic problems faced by the ASCA countries are of similar nature, a cooperative endeavour in tackling these problems would be feasible and profitable," he added.

Prof. Y. Nayudamma, Director-General, CSIR and leader of the Indian delegation was elected Chairman for the Third ASCA Meeting. In his address, Prof. Nayudamma suggested setting up of a working group to develop alternative strategies and technologies which are more agro-based to suit the resources and needs of most countries of this region whose problems are similar to those in India.

In the Technical session reports on cooperative projects were presented. There was unanimous support for the new project on low-cost housing and fire research proposed by India. It was decided that a Seminar be organised in which those active in the field should participate. The Seminar session on the theme of "Integration of Science and Development Planning" discussed the desirability of setting up a working group of experts from interested ASCA countries to facilitate fruitful sharing of experiences in this field.

A number of participating countries expressed interest in cooperative endeavour in areas such as high-yielding varieties of staple food, edible protein, marine resources, weather modification, low-cost housing, non-conventional energy sources, etc. On a suggestion from India, it was agreed that each interested country would prepare a preliminary list of projects. Once a few projects were identified, the leading country in respect of each of these projects would take the role of identifying the methodology in implementing the projects. The meeting concluded with the signing of a joint communique by the participating countries.

Biman Basu

SCIENCE FOR THE YOUNG

Mesoxhelet apparatus

SEMI-MICRO and micro-analyses are fast replacing the macro-techniques in the laboratory. During analysis of organic compounds, the student is often called upon to separate components of mixtures. One of the methods of separation of a mixture of two solid components is by Soxhelet extraction. In principle, it is continuous extraction of a component of the mixture using a solvent at its boiling point.

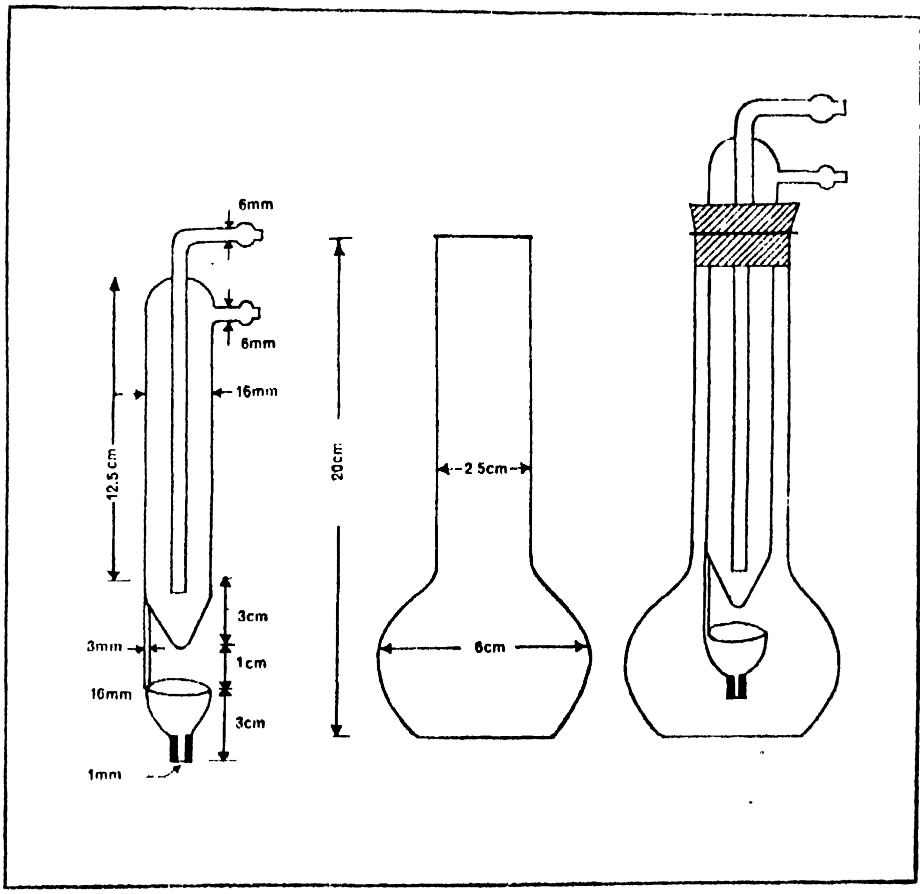
Mesoxhelet is a Soxhelet apparatus working on a meso or semi-micro scale. In physical appearance, it has little in common with the the macro soxhelet apparatus. That is how it ought to be because meso apparatus need not, and very often is not, a mere miniaturization of its macro counterpart. Nonetheless, the principle of operation remains the same in both the cases.

Mesoxhelet apparatus consists of a flask fitted with a cold finger from the tip of which hangs a tiny funnel. The cold finger serves to reflux the solvent and the tiny funnel at the tip is the support for a thimble. The bottom of the cold finger, instead of being spherical, is drawn out into a tip so that the condensed vapours (liquid) of the solvent drip down from the tip straight into the thimble. The cold finger tip stands 1 cm above the rim of the funnel. The thimble can be a Whatman No. 1 filter paper, folded in the form of a fluted cone. The stem of the thimble-supporting funnel is made of a 1 mm capillary, so that the liquid collecting in the thimble can flow out only drop by drop, thereby remaining sufficiently long in contact with the material to be extracted.

The reflux assembly is fitted on to the flask through an ordinary bark cork and is so mounted that the stem of the thimble-carrying funnel stands 1/2 cm above the liquid level. The flask is heated in a beaker of water or with the help of a micro-flame depending upon the boiling point of the solvent used. When liquid baths are used for heating, the temperature of the bath is generally maintained at 10 °C above the boiling point of the solvent.

Extraction

The material to be extracted is mixed with some inert inorganic material such as calcium carbonate or alumina to make it pervious to the solvent. It is then loaded into



Dimensional details of the apparatus

the thimble supported by the funnel. Dimensions of the assembly are shown in Fig. 1 (not drawn to scale). Using 5 ml of methanol and keeping the bath-temperature at 75 °C, it was observed that the whole quantity of the liquid cyclised on an average about 12 times per hour (measured from the number and volume of drops trickling from the funnel). With ethanol or benzene at 90-95 °C temperature the same rate of cyclization was maintained. Using 0.8-1.0 gm of green leaf powder macerated with 1 gm of alumina (total charge 2 gm) and with 5 ml of methanol as solvent, the extraction of chlorophyll was completed in 30 minutes, i.e., in about 6 cycles of the solvent, equivalent to a continuous counter current extraction by 30 cc of hot alcohol. Similarly, using 5 ml benzene as solvent, the vehicle from 1.5 gm of white lead paint could be extracted in about 25 minutes. The assembly is elegant and convenient to extract quantities ranging from 0.5 gm to 3 gm.

P.B. JANARDHAN

1P	O	L	Y	2M	E	R			3M		4V	U	L	C	A	N	I	T	5E
E		6I	S	O	P	R	E	N	E										T
R		7V	8I	N	Y	L			K										H
I			N	O							9O	S	M	O	M	E	T	R	Y
S			H	M															L
T		10Z	I	E	G	L	E	R		11I		12B	A	K	E	L	I	T	E
O			B	R						13S	I	L	I	C	O	N	E		N
N			I				14N	Y	L	O	N		15L	A	T	E	16X		E
			T					17C	A	T	A	L	Y	18S	19T		Y		
20R			O	21C		22A	V	E	R	A	G	E		I	E		L		23C
24E	N	T	R	O	P	Y				C				L	F		E		E
D				R		25L	U	C	I	T	E			K	L		N		L
26O	R	L	O	N			27C	H	A	I	N				O		E	28M	L
X		29F	R	E	E	R	A	30D	I	C	A	L			N			A	U
				A				P										C	L
31D	N	A							32D	A	C	33R	O	N				R	O
Y		34E	L	A	35S	T	O	M	E	R		36A	S	B	E	S	T	O	S
E					O		37C	O	P	O	L	Y	M	E	R				E
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Solution to puzzle published in *S.R.*, March 1974

MEDICAL NOTES

(*Continued from page 255*)

and pressure, ensures complete and effective sterilization.

The new "artificial" bone has not yet been tested either in animals or humans to know its acceptance by the living beings and the likely complications its use might create. If the new substance could prove satisfactory after such trials, it will mean another step forward, a major step, in bone transplantation.

P.K. TATINENI

SCIENCE IN INDUSTRY

Electrolytic copper powder from copper sheet

COPPER powder finds application in powder metallurgy for the manufacture of sintered complicated shapes and porous, self-lubricating bearings. Copper powder of 300 mesh size is used as a toxin in certain types of antifouling paints for ship bottoms. Further, organic chemical industries utilize fine copper powder as a reductant.

Copper powder is being produced in the country by some firms. However, their production is inadequate to meet the present demand, and part of the requirement is met by imports.

There are three methods available for the production of copper powder: (i) spraying molten metal through fine nozzles into an inert gas; (ii) reduction of oxides of copper in a furnace; and (iii) deposition by electrolysis from a copper solution. Of these, the most preferred is the electrolytic method because of its simplicity, elegance and the high purity of the product. Powders of varying particle sizes could be readily prepared by suitably modifying the conditions of electrodeposition. The Central Electro-Chemical Research Institute (CECRI), Karaikudi has developed know-how for the electrolytic production of copper powder from copper sheet.

The know-how for making copper powder to suit different applications is generally not available in India. Adopting the process developed by CECRI, it is possible to set up a plant to meet the present indigenous requirement. The effects of the various parameters on the deposition have been studied and the preferred working ranges of concentrations have been worked out. The conditions of stabilization, which constitute a crucial step, have been worked out.

The process has been studied on a bench scale using 200 amp cell. A bench scale unit capable of producing 1.5 kg per 8-hr day was operated for about a month.

The main raw materials required for the process are: copper scrap, copper sulphate, sulphuric acid, ammonia liquor and stabilizer, and all these are available in the country.

The items of plant and machinery required are: rectifier, R.C.C. pitch-lined cells, storage tanks, pump sets, centrifuge, vacuum shelf drier, grinder, air classifier, bushbars, grinding and buffing sheets, weigh scale, reduction furnace, and distilled water plant.

The total investment on a plant capable of producing 150 tonnes of copper powder per annum has been estimated at Rs. 15.27 lakh (comprising Rs. 1.50 lakh as fixed capital on building, Rs. 3.57 lakh as fixed capital on plant, and Rs. 10.20 lakh as working capital).

Production of titanium alloy powders : Studies at NAL

ONE of the promising structural materials to emerge in this decade is titanium. The fourth most abundant element in the earth's crust, titanium has all the desirable properties: it has a strength-to-weight ratio higher than that of steel, excellent resistance to corrosion, and a high melting point. All these properties individually, or in combination, make titanium a very attractive material for engineering application both in aeronautical industry, where the specific weight is of importance, and in other industries as well.

Titanium is being increasingly used in aircraft industry. Its light weight and high temperature capability make it an attractive material for air frames, structures as well in aeroengines. In the USA alone about 10,000 tonnes of titanium are being used annually in aerospace industry. Titanium is also beginning to be used increasingly in chemical industries. In USSR 80% of the annual production of titanium is used in chemical industries. Titanium has a longer service life and has a better resistance to corrosion attack in aggressive environments compared to its rivals, stainless steel and nickel alloys. The world annual production of titanium is estimated at 40,000 tonnes and is expected to increase considerably in the near future. The price has also fallen from Rs. 120 to about Rs. 18 per kg.

India has vast reserves of titanium. Ores occur as ilmenite, and reserves are estimated at 300 million tonnes. These are found mainly in the beach sands of Kerala and Tamil Nadu. Titanium metal production is now being attempted on a small scale and a pilot plant to study the feasibility of various routes for the metal production is being established at the Nuclear Fuel Complex, Hyderabad.

In order to make titanium a very useful structural material in the national economy, attempts must be made to reduce the cost of the metal. The high price of titanium is partly due to the difficulty of melting a reactive metal and fabricating it and also due to the difficulty of re-utilizing the scrap. This is a serious problem as it is estimated that sometimes 80% of the metal ends as scrap. This can be avoided if titanium structural parts could be fabricated through powder route. Powder metallurgy techniques reduce the scrap problem considerably as there is practically no wastage. The main difficulty in choosing this route is the production of high-purity titanium powder. Because of its extreme reactivity, fine titanium powder gets quickly contaminated with oxygen, the main impurity. The National Aeronautical Laboratory (NAL), Bangalore, is now working on the production of titanium powder of good reproducible quality. A novel electron beam set-up, called electron beam splatting furnace, has been designed and built. Sponge titanium is melted in an electron beam furnace and molten drops are frozen quickly into fine flakes. These are then mechanically alloyed and comminuted by a novel set-up, designed and built at this laboratory. Both these equipments are the first of their kind to be built in the country. It is hoped that by the use of this technique it would be possible to produce titanium alloy powder which can subsequently be consolidated and sintered. This route has the possibility of reducing the cost of the finished products considerably. Another potential application of the electron beam splatting furnace would be in the recycling of the scrap. By careful alloying additions, the impurity contents could be reduced to acceptable level. The furnace is capable of producing about a kilogram of powder in a single operation and can be operated almost semi-continuously. Development of powder metallurgy techniques and cheap commercial alloys of titanium augar well for titanium becoming a useful structural material next only to steel and aluminium. Research and development activities on titanium at NAL are directed towards this end.

High voltage ceramic capacitors

HIGH voltage capacitors are used in the manufacture of television and professional electronic equipment. At present, such capacitors are being imported. The National Physical Laboratory, New Delhi has developed a series of disc type high voltage ceramic capacitors to meet the growing demand of the electronics industry.

The process of manufacture consists of mixing the raw materials in the required proportion, wet ball-milling, drying and calcining at a temperature of 100 °C. The calcined material is pulverised and pressed into the required shape. The pressed discs are fired and provided with electrodes and leads. Finally, the discs are encapsulated with a phenolic resign and vacuum impregnated with micro-crystalline wax. The capacitors so formed are tested for capacitance and dielectric strength.

Two types of capacitors with special electrodes and leads configuration have been developed and are being batch-produced for supply to the industries: (i) temperature compensating (TCD) capacitors suitable for use in resonant circuits or any other application where low loss and high stability are essential, and (ii) general purpose (MKD) and HKD) capacitors suitable for bypass coupling and general applications.

Capacitors of various values in the range of 25-400 pf for working voltages of 1 kV to 4 kV have been developed. The raw materials and machinery are indigenously available.

The NPL-produced capacitors have been supplied to leading manufacturers of TV and electronic equipment who are using them in their equipment. The estimated annual demand for high voltage capacitors by the end of 1978-79 is two million pieces.

BOOK REVIEWS

HANDBOOK OF BASIC TRANSISTOR CIRCUITS AND MEASUREMENTS

by R.D. Thornton, J.G. Linvil, E.R. Chenette, H.L. Ablin, J.N. Harris and A.R. Boothroyd, *Wiley Eastern Private Ltd., New Delhi,* 1973, Pp. 156, Rs. 12/-.

IN America in 1960, a committee known as Semiconductor Electronics Education Committee (SEEC) comprising members from academic and industrial fields, was formed to procure and prepare new educational materials on semiconductor devices and transistor electronics for teaching students in the undergraduate levels. As a part of SEEC-programmes, seven paperback volumes were brought out. The topics were basically elementary and include among others, physics of electrical conduction in semiconductors, device characteristics, circuit models and circuit applications and designs. In all the volumes, the relationship existing between the internal physics of transistors and their capabilities and limitations are brought out. Junction diodes and transistors are mainly chosen as devices for discussion in the series. The present book is the last in the series and was first published in the U.S.A. in 1966.

This volume deals with a number of specific, pre-tested circuits with sufficient descriptive material so that they may serve as the starting points for other experiments. By the time this book was produced, a number of manufacturers had brought out handbooks and manuals on transistor characteristics, practical circuits and many representative practical applications. From his point of view, it will be a good idea to use the information given in this book in conjunction with the materials given in other publications.

B.B. GHOSH

ANNUAL REVIEW OF ECOLOGY AND SYSTEMATICS

Vol. 3, Pp. 520, $10.50; Vol. 4, Pp. 424 $12.50, *Annual Reviews Inc.*, USA.

EACH volume contains 16 papers of varied and diversified nature which can collectively be classified as a part of the human ecosystem. Yet each of them is independent in itself with discussions ranging from olfactory communication in mammals, competition among rodents, the structure of lizard communities and ecology of foraging by ants, to the role of thermodynamics in ecology character convergence, geographic variation, cultural evolution of civilizations, and mineral cycling.

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As in the previous volumes, the standard of papers is very high ranging from futuristic studies and current research to accepted facts and general concepts in ecology and systematics.

S.K. GHASWALA

FREE RADICALS

(*Continued from page 231*)

hydrocarbons is one of the important free radical reactions used in industry. Hexachlorobenzene, the well-known insecticide, is manufactured by photochlorination of benzene. Similarly chlorinated solvents, perchloroethylene, etc., are the fruits of such industrial photochlorination processes. Recently, in Japan, Nylon 6 via caprolactum has been manufactured by photochemical route (See *Photochemistry in Industry, S.R.* August, 1972).

Further reading

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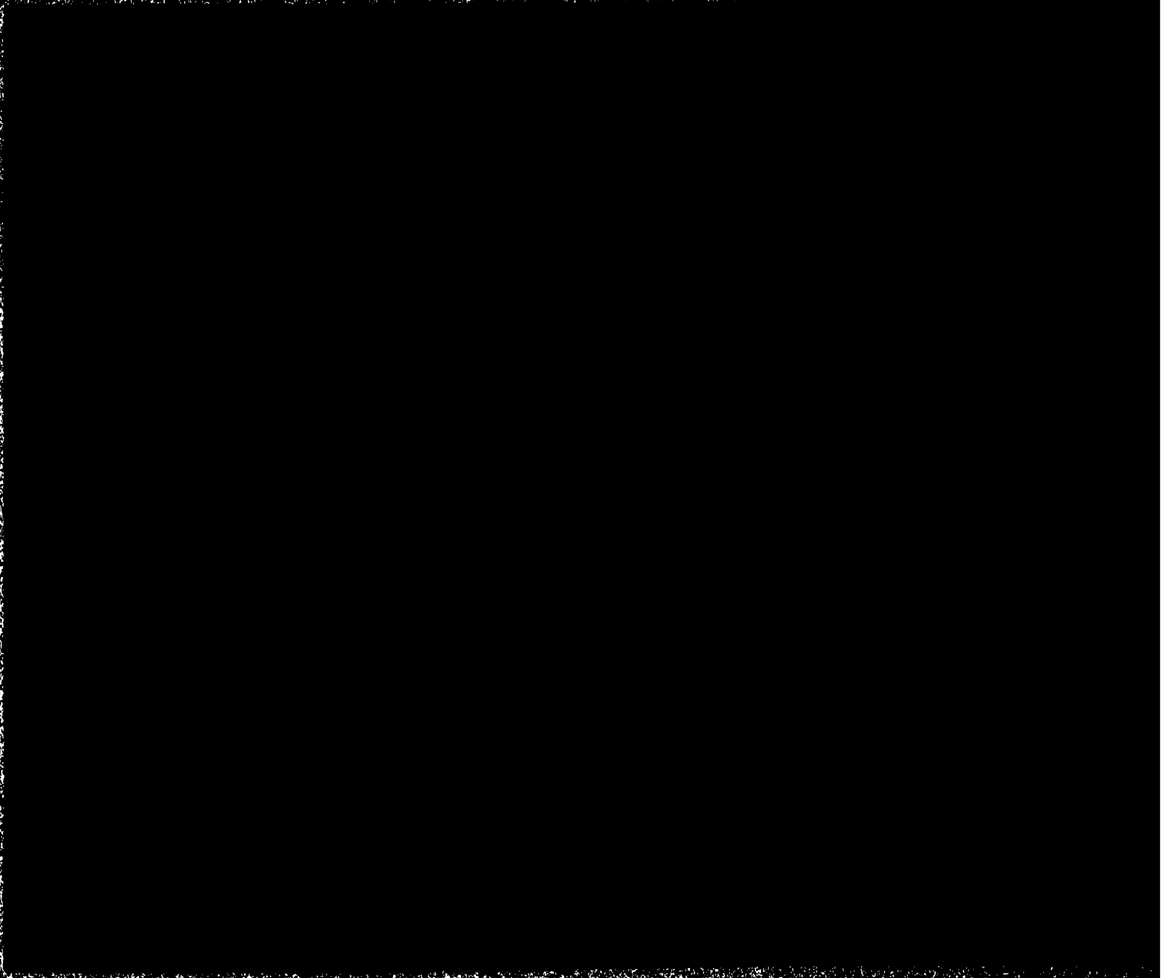

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LETTERS

Acupuncture

Sir, Thank you very much for publishing an article on 'Acupuncture' (*S.R.* February, 1974). I would like to add the following:

There is no scientific basis of acupuncture. It cannot be explained by our knowledge of the anatomy and patho-physiology of the nervous system. Identical results have not been obtained from acupuncture of identical cases, and hence it is not surprising that in China, the home of acupuncture, it is done in selected cases only. It is intriguing that the western world is more enthusiastic about it than the Chinese. Contrary to the claims by the author of acupuncture, it has had little impact on modern medicine. The future value of acupuncture depends on the realisation of its claim.

SURJIT BHATTACHARYA
Nilratan Sircar Medical College
Calcutta

Articles

Sir, I am a regular reader of *S. R.* and I find it very useful too. As a technologist and engineer, I regret to say that *S.R.* is lacking in technological reports. Most of the pages carry articles on biology and medicine only. May I request you to give equal importance to various fields of engineering and technology in future ?

ER. S. M. KALANTHAR MASTHAN
Civil Engineer
Kadayanallur

Pramaṇa

Sir, Analysing the validity of the name *PRAMĀNA* for a physics journal (*S.R.* February, 1974), G.H. Keswani has remarked that "this would be too tall a little for any scientific journal." He has based his analysis on the meaning forwarded by the editor of the journal as "source of valid knowledge." But, in fact, this is not the true meaning of *PRAMĀNA*. Out of its various meanings given in Sir M. Monier-Williams' *Sanskrit-English Dictionary* (1956), the following ones seem to be appropriate:

i. a means of acquiring 'Prama' or certain knowledge,
ii. any proof, a testimony or evidence,
iii. standard, etc.

Even logic, I think, cannot be labelled as source of valid knowledge as Shri Keswani asserts. This also is one of the instruments applied by human mind to arrive at valid knowledge. Talking in a broader sense the only source of all forms of knowledge would be nature. The cause of revelation of knowledge is human mind which employs various means to achieve it.

PRAMOD KUMAR SINGH
AIIMS, New Delhi

Blood groups

Sir, In "Blood groups and blood transfusion" (*S.R.* January, 1974) by Tripta Datta and Surinder Chhina, I read something on *Rh*-factor also. I would appreciate if "The M-N blood type" is explained in your magazine.

J.L. SHARMA
Dibrugarh (*Assam*)

Science aids Industry

Sir, I request you to publish articles on cottage industries and small-scale industries in the section *Science in Industry*. These industries make use of rural raw materials available in most of our villages. They can encourage self-employment among engineers.

V. BALAKRISHNA
Parmanchala
Kurnool (*A.P.*)

Mushrooms

Sir, The article "Mushrooms for food" (*S.R.* October, 1973) was an important one regarding our food problem. The author did not mention how to distinguish between poisonous and non-poisonous mushrooms. Please let us know how to do this.

K. NARAYANAN KUTTY
Trichur, (*Kerala*)

There is no general 'rule' or known test by which one can distinguish between poisonous and non-poisonous mushrooms. The only safe test is 'experience' according to Ramsbottom, a renowned mycologist of Great Britain. It is not judicious to treat a fungus as either non-poisonous or poisonous unless its identity has been established by an expert. A number of so-called tests may be mentioned for information only, but none of them is reliable. Silver spoons or coins are said to turn black when dipped into a dish of cooked poisonous mushrooms. Poisonous species are said to peel off readily. Species that are brightly coloured have undesirable odour or a bitter taste when freshly collected are usually found to be poisonous. Besides, exudation of 'milk' from a damaged fruit-body, change in colour of the flesh, coagulation of milk, a change in colour of onion or parsley in cooking are also considered characteristic features of poisonous mushrooms. All these tests are, however, not conclusive. Bessey, an American mycologist, states that almost all fungi which have reached a state of incipient decay are dangerous. According to him, the blackening of silver surface is due not to the poison naturally occurring in the fungus but to the products of incipient degeneration. *Amanita muscaria*, a deadly fungus, can be peeled off as easily as many non-poisonous field mushrooms. Some species are too small, or tough or slimy in consistency or of disagreeable odour or taste even though not poisonous. A number of mushrooms namely *Amanita muscaria*, *A. phalloides*, *A. verna*, and many others are considered poisonous while *Agaricus campestris*, *A. bisporus*, *A. ostreatus*, and some others are non-poisonous. Poisonous *Amanita* have white spores, are rather tall and possess on their stipes both ring and volva. The non-poisonous meadow mushroom *Psalliota campestris*, on the other hand, has purple brown spores, is short, squatty and possesses only a ring and no volva.

DR. R.P. PURKAYASTHA
Dept. of Botany
Calcutta University

Snake venom

Sir, 'Snake venom' (*S.R.* November, 1973) was quite informative as well as interesting. I would like to know:

1. What are the nerves that induce ejection of venom from poison gland ?
2. What are the medicinal uses of snake venom?
3. How is the digestion in poisonous snakes accomplished in the absence of functional salivary gland?
4. How far is the statement correct that if swallowed, venom acts as a good digestive juice since its poison is ineffective on uncut surfaces?

S. AFTABUDDIN
Science College, Patna

1. Snake venom is ejected from the poison gland by the stimulation of parasympathetic nerves.

2. The dilute solution of Cobra venom is used as a safe, potent, pain killer (anodyne) in inoperable cases of cancer and neural leprosy. It is also said to relieve arthritic pain and migraine. More recent studies have highlighted the positive use of Cobra venom in minute quantities for the inhibition and destruction of tumours and cancer cells in mice. Investigations on these lines have been successfully conducted at the Cancer Research Institute, Bombay.

In Ayurvedic system of medicine, the venom is used as an essential constituent of medicine for tuberculosis as also to raise body temperature. It is remarkable that in some Homoeopathic medicines Krait venom is used as a constituent. Russels viper venom is used to stop bleeding in dental operations and haemophilia. Cardiotoxin in small doses is known to bring about the dilation of coronary vessels and can therefore be used in the treatment of coronary thrombosis. Venoms are a rich source of highly concentrated proteins, toxins and enzymes. Further investigations in the field would certainly reveal many other uses of venoms.

3. In order to explain digestion in poisonous snakes in the absence of normal salivary glands, it should be well understood that the venom itself is a mixture of highly concentrated enzymes, proteins and toxins. The enzymatic components digest the food (tissues of the prey) and thus rank the poison glands equal to the functional salivary glands.

4. It is correct to say that the poison is effective on the cut surfaces. The prey swallowed by a poisonous snake will be having poison injected into its body (envenomation) and not smeared on it (uncut surface). The injected venom thus swallowed alongwith prey acts effectively in digestion.

BUDH DEV SHARMA
Head, Zoology Dept.,
Govt. Degree College
Poonch (J & K)

Tea

Sir, I read with much interest "Tea—from garden to the pot" by B.C. Marwaha (*S.R.* October, 1973). I would like to know whether the grade of tea depends on the age of the leaves.

ENAM NABI SIDDIQUI
Bhagalpur University
(Bihar)

There is an approximate division between the grades made up of tender shoot parts and of the more tough and mature parts of the same plant. The more mature leaf which becomes coarse and hard would break during rolling to give a greater percentage of broken grades (e.g., B.O.P., B.P.F.) and dust grades than the tender leaf plucked at the right time. The grade of tea depends on the age of leaves.

B.C. MARWAHA
Tea Experimental Station
Kangra (H.P.)

Bose and Einstein

Sir, Mr. G.H. Keswani has paid a glowing and respectful homage to Prof. S.N. Bose in your issue of March 1974. We thank him for that. There is, however, one controversial point that he has touched upon in his obituary which in the interest of history and the fair name of Prof. Bose should not be allowed to go unchallenged. Mr. Keswani says, "W.A. Blanpied tells us that Bose never got an opportunity to work with Einstein". In its issue of 18th February 1974, the noted American weekly, *Time*, also wrote in the course of its obituary of Bose,"....though he had never met Albert Einstein." There are internal and external proofs in existence which go to show that both Blanpied and *Time* were misinformed.

Mr. Keswani's statement, "It

appears according to one report that Einstein had welcomed Bose into an inner group of physicists (called the colloquium) during Bose's stay in Berlin, but this is not certain in view of what Blanpied has recorded in the *American Journal of Physics* which was published while Bose was alive," is not convincing. In the first place we cannot accept Blanpied's words as Gospel truth. Secondly, Mr. Keswani himself says, "In his humility, Bose was extremely extreme." It is therefore quite likely that Bose did not contradict Blanpied due to his excessive modesty and his total lack of aggressiveness or egotism.

Prof. Bose wrote and published several articles in Bengali about Einstein. In one of them he has himself written, "During my stay in Germany, I could easily get admission into all the scientific organisations there. Besides, like all German professors, I was allowed the privilege of borrowing books from State libraries and taking them home to study—all through the influence of my *guru* (Einstein). When I reached Berlin in 1925 the Einstein family lived in a small flat at 5, Heberland Strasse. It was my good fortune to visit him there on many occasions and have long discussions with him on diverse subjects. Since then, I have not met Einstein. There was, however, exchange of letters between us now and again." (Arrangement is under way to publish all Bose's Bengali writings in a collected form.)

In another place Bose said that he was not only admitted to the colloquim of physicists in Berlin through the influence of Einstein, but Einstein also introduced him to all the famous German physicist members thereof. The colloquium also made Bose its visiting member.

Further, one or two German physicists who are still alive and who had direct communication with Einstein and Prof. Bose can still confirm that not once, but several times, Bose had met his *guru* in Berlin. One of them is Prof. Herman Mark, at present with the Polytechnic Institute of New York, U.S.A. On Bose's death he wrote in his condolence letter to Bose's family—"His (Bose's) scientific invitation was such that he even sparked the mind of a genius like Einstein......I was fortunate to witness several meetings of these great minds."

There are numerous evidences of the meeting of the *guru* and his pupil. The above should wholly disprove both Blanpied and *Time*'s views. They should also finally dispel any doubt among the present generation as to whether or not Einstein and Prof. Bose had ever met in Berlin during his sojourn to Germany in 1925. That is most important from the national point of view.

A.P. Som
Jamshedpur

Klystron power supply

Sir, I just went through the article on "Universal klystron power supply and modulation unit" (*S.R.* March, 1974). It is claimed that klystron power supply and modulation units are not manufactured in India. I would like to bring to your notice that Electronics Corporation of India Ltd. makes such items. The model number of their klystron power supply is Type U 475 signal source. It has facilities for Internal AM, FM and external FM too. Though the cathode voltage is 250-300 V and repeller voltage is 10 to 250 V (negative with respect to cathode), this is suitable for microwave test benches and we have used it in our laboratory.

P. Rajendran
I.I.T. Delhi

Mitochondria

Sir, Re: Mitochondria (*S.R.* April, 1974), the author has provided a beautiful insight into the biochemical functions of mitochondria. He has, however, not mentioned anything regarding the exciting phenomenon of mitochondrial replication and the theory that these cell organelles could possibly be 'invaders' into the cell which have later become intracellular symbionts. It has been suggested, for example, that mitochondria are relatively recent arrivals in the cell and that their appearance enabled higher organisms to cope successfully with an atmosphere which was becoming increasingly rich in oxygen due to the activity of the photosynthetic organisms. This is an attractive theory involving some fascinating speculations on the evolution of metabolic pathways.

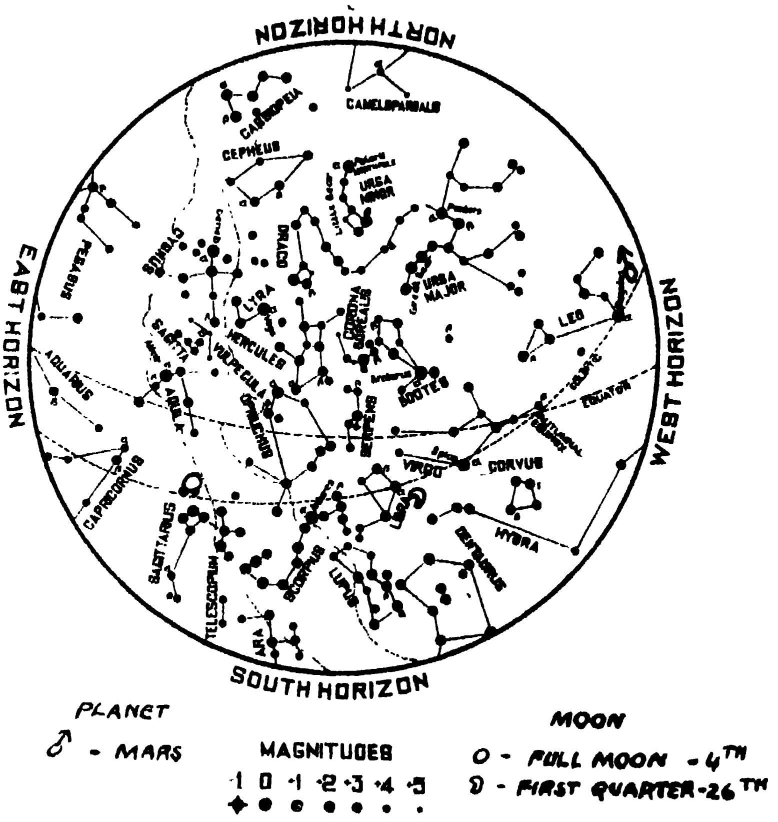
Most workers believe that in growing cells new mitochondria arise by the growth and division of pre-existing mitochondria. It seems likely that relatively large subunits are incorporated into existing mitochondria and replication eventually occurs by fission.

It has recently been shown that mitochondria can synthesise some but not all of their lipids and can incorporate labelled amino acids into their membrane protein. Though much of the mitochondrial fabric is synthesised at extra-mitochondrial sites under the genetic control of nuclear DNA, it, however, contains its own genetic capability (though a limited one) as shown by the presence of DNA in these organelles. A peculiar bacteria-like protein synthesis mechanism enables the organelle to synthesise a small portion of its own proteins.

These facts, coupled with the mitochondrial size, its oxidative activity and capacity for ion transport have led scientists to propose that mitochondria are highly evolved

(*Continued on page 303*)

PLANETS AND THEIR POSITIONS—JULY 1974



The moon

FULL moon occurs on 4th at 6-10 p.m. and new moon on 19th at 5-37 p.m. I.S.T. The moon passes about seven degrees north of Jupiter on 10th, about half a degree north of Venus on 17th, two degrees north of Mercury and one degree south of Saturn on 18th and about six degrees south of Mars in the evening of 21st. The lunar crescent becomes first visible after the new moon in the evening of 21st in the northern part of India, while it is likely to be visible one day earlier in the southern and western parts of the country.

The moon is at apogee or farthest from the earth on 7th and at perigee or nearest to it on 20th. The earth is at aphelion or farthest from the sun on 5th.

The planets

Mercury (Budha) is too near the sun to be visible during the first half of the month being in inferior conjunction on 1st. Thereafter, it reappears as a morning star and rises about an hour before sunrise. It becomes direct on 12th and is at the greatest western elongation of about 20 degrees from the sun on 22nd. It passes about a degree south of Saturn on 24th. It is in Gemini (*Mithuna*). Its visual magnitude varies from +1.7 to —0.6.

Venus (Sukra), a morning star, rises about two hours before sunrise during the month. It passes about four degrees north of the star Aldebaran (*Rohini*) on 4th, and very close to Saturn, being about a quarter degree north of it on 31st. It moves from Taurus (*Vrishabh*) to Gemini (*Mithuna*). Its visual magnitude is about —3.4.

Mars (Mangala), visible in the evening sky, sets about two hours after sunset during the first half of the month and about one and a half hours after it during the second half. It passes about a degree north of the star Regulus (*Magha*) on 26th. It moves from Cancer (*Karkata*) to Leo (*Simha*). Its visual magnitude is about +2.0.

Jupiter (Brihaspati) rises about three and a half hours after sunset during the first half of the month and about two and a half hours after it during the second half. It becomes retrograde on 7th. It is in Aquarius (*Kumbha*). Its visual magnitude is about — 2.3.

Saturn (Sani) is too near the sun to be visible during the first half of the month. In the second half it reappears in the morning sky and rises about an hour before sunrise. It is in Gemini (*Mithuna*). Its visual magnitude is about +0.3.

(*Source*: Nautical Almanac Unit of the Meteorological Office, Alipore, Calcutta-27).

CYCLONES

The Terror of The Tropics

RADHA KANT BHARATI

Originating in the tropical seas these violent whirls of rain and winds cause havoc with coastal life and property

CYCLONES, or cyclonic storms which usually originate in the Indian seas, inflict heavy damage on animal life and property in the coastal areas each year. Apart from this, they pose a great thriat to ships in the high seas as well as those lying at or near the ports. In the Indian sub-continent they occur generally in the pre-monsoon (April and May) and post-monsoon (October to December) periods.

Geographically known as tropical cyclones, these storms have their genesis near the equatorial belt. Accordingly, they take form over all of the tropical oceans except the South Atlantic and the continental land mass. In different regions of the world the tropical cyclone is known by different local names: as typhoons in the western North Pacific Ocean, as cyclones in the Bay of Bengal and the Arabian Sea, and as hurricanes in the areas of North Pacific, southern Indian and North Atlantic Oceans including the Gulf of Mexico and the Carribean Sea. They call it 'Baguis' in the Philippines. The blasting winds of cyclones are called "Willy-Willies" in Australia.

The term 'cyclone' was originally coined at Calcutta in 1848 by one Capt. Henry Pedington, the then Chairman of Marine Court, Calcutta. The word is derived from a Greek word *Kyklos* meaning, 'the coils of a snake'. Thus the expression of the word 'cyclone' is very significant and symbolic; it gives the realistic picture since the rainbands in the cyclone, as revealed 100 years later on radar screen, resemble moving serpentine coils (*see cover*).

Origin of cyclones

Cyclones are generally formed from a pre-existing low pressure area on an easterly wave over the warm tropical ocean. After the cyclone is born, the turbulent sea surface provides it with an inexhaustible and continuous source of moisture. Due to this, the cyclonic storm picks up strength and moves forward slowly towards west and north-west in the northern hemisphere. In the southern hemisphere, it turns to west and south-west directions.

A tropical cyclone, when fully developed, is a vast, violent whirl of air which may extend from 150 to 1000 km. The circulation of a large cyclone may even cover a good part of the Bay of Bengal. But at times it remains smaller like the one which appeared near Orissa coast in 1967. It was of less than 150 km in diameter. In the vertical direction cyclonic circulation extends up to 10 km. The length of the track of a cyclonic storm varies considerably over the sea and land surfaces. It may be 800 km and extend upto 1000 km and more specially during pre-monsoon or post-monsoon season.

Shri Bharati is a research officer with the CWPC Water Wing), New Delhi.

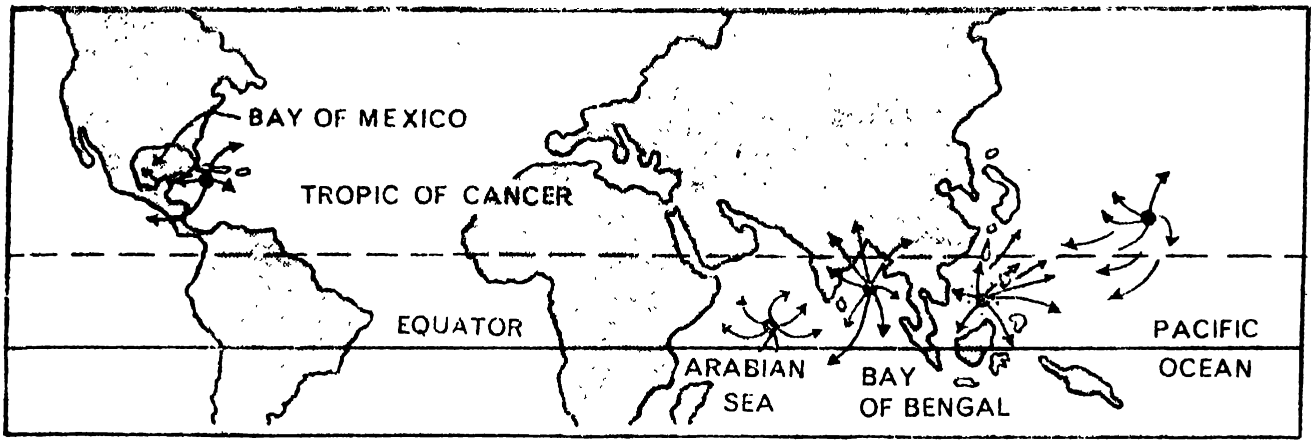


Fig. 1. Cyclonic areas of the world

The normal travel rate of a cyclone is 300 to 600 km. p.h. However, the rate of travel varies from one cyclone to another and also at different times in the same cyclone. Some of the cyclones have been known to remain stationary for two to three days in the same area while others have travelled beyond 5000 km. within a few hours. Cyclonic storms mainly move in a curved path, but there are occasions when they flash in a straight route or make zig-zag movement.

The process of evolution of normal cyclone has been broadly divided into four stages, namely, the formative phase, developing phase, mature phase, and dissipating phase. During the formative phase, winds are variable with squall showers of rain on a large oceanic region leading to the fall of atmospheric pressure gradually over the whole region. On the weather chart winds over parts of this region exhibit departure from their prevailing direction and isobars (the lines of equal pressure) drawn on the map and take up close, rounded shapes covering the sea-surface from 1000 to 2000 km. The Weather Services usually name such weather over these areas as "unsettled". Many of such weather disturbances fail to develop further, but several others develop further to take complete shape.

In the developing phase with the continuous fall of pressure, the wind speed increases and takes a difinite anti-clockwise direction of motion around a central region (in northern hemisphere). During the period of development squalls increase, extensive area of sky become heavily over-cast and the rain starts. The meteorological services usually describe this phase as a "depression". This expression is used by the India Meteorological Department as long as the winds over the disturbed area remain less than 33 knots (60 km.p.h.). From this stage onwards, the area of low atmospheric pressure and the associated wind begin to acquire a progressive movement along the oceanic surface at the rate of 300 to 500 km a day. Many of these depressions do not develop further, some develop beyond this phase into mature tropical cyclones; only a few develop into severe tropical cyclones. The term "cyclonic storm" is used when the wind speed exceeds 33 knots and the expression "severe cyclone" when the wind speed exceeds 48 knots (85 km.p.h.) with occasional squalls of 64 knots (118 km.p.h.) or more.

The climax of a cyclone is reached during its mature phase. In this phase, a tropical cyclone is said to be "severe" with the following characteristics:

(a) A calm central area varying between 7 to 35 km in diameter where calm air or light winds with clear or partly cloudy sky prevail, technically called the 'eye' of the cyclone.

(b) An inner ring of fast blowing hurricane winds (90 km.p.h. or more) 50 to 100 km in width within which the pressure fall is excessively steep with squals and heavy rains. This constitutes "the eye-wall".

(c) In outer storm area, within which the winds decrease outwards from the eye-wall but still remain as strong as gale force.

(d) The outermost area of weak cyclonic circulation with light winds.

After reaching the height of climax the anti-climax is a natural process. Soon after the ring of cyclonic storms enters a land-mass the dissipating phase sets in. The increased frictional effects of topographical features of land and lack of moisture supply in absence of a warm oceanic surface rapidly decrease energy supply into the system. The blowing winds weaken and the atmospheric pressure at the centre registers a rapid rise. The rainfall, however, continues to be heavy.

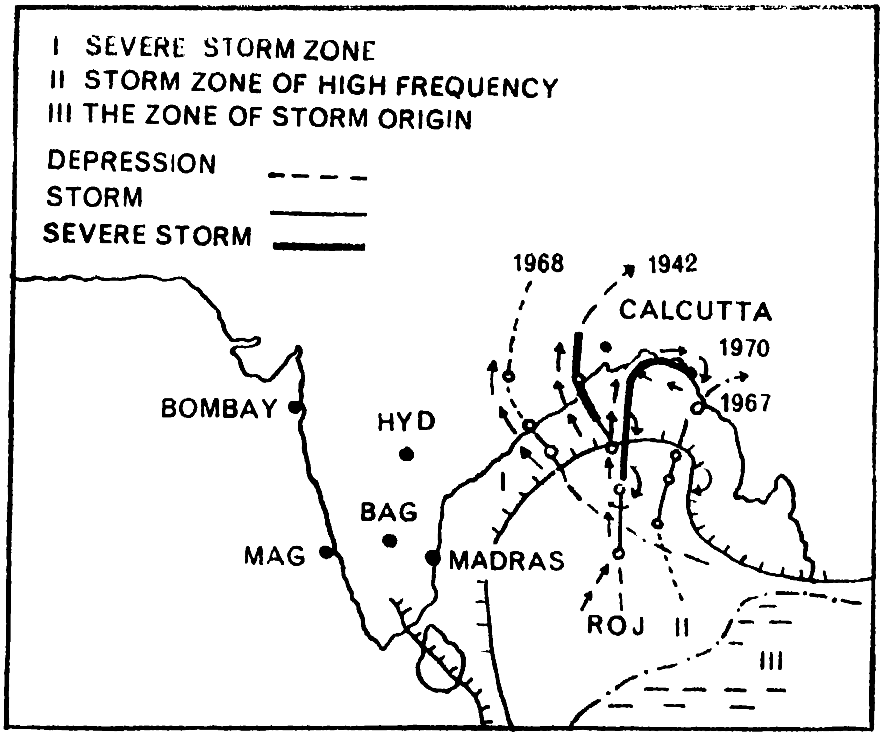


Fig. 2. Cyclonic tracks in the Bay of Bengal

Cyclonic areas

The tropical cyclones, as their name denotes, originate over the comparatively warm oceanic surfaces in the tropics, a few degrees away from the Equator, and tend to move pole-wards in either hemispheres. In the areas of Indian Ocean, specially in the Bay of Bengal and the Arabian Sea, cyclones generally form between 5° N and 15° N latitude during pre-monsoon and post-monsoon seasons. On their path towards the Indian sub-continent these cyclones pick-up tremendous amounts of moisture. The tropical cyclones of the Bay of Bengal moving west or north-west strike the east coast of India and those taking north-east direction hit Bangla Desh and Burma coast. The Bay of Bengal is known all over the world for its severe type of cyclones.

The tropical cyclones of the Bay of Bengal are more dangerous because of the presence of certain factors which provide favourable factors for the severeness of the storms. In this area, the conditions along the shore are more favourable for tidal waves, specially at the head of the bay. Even the daily tide, due to gravitational forces, is developed to a much greater extent than any other point in the sub-continent. These conditions combine to produce much more severe storm waves, especially when the time of high water coincides with the arrival of the storm wave. Here the storm wave arrives as a sudden rise of water, sometimes as an advancing wall of water and at other times as a bore.

During the cyclonic storm in the coastal area the sea water inundates the land and creates havoc. Extensive cattle population gets annihilated, huts and houses collapse, and arable land is salted up due to flooding with sea-water. It has been estimated that a greater loss of human life and property is caused by these unexpected and high tidal waves than any other natural calamity. Along the eastern coast of the sub-continent the seaside areas of Tamil Nadu, Andhra Pradesh, Orissa, West Bengal and Bangla Desh are vulnerable to the maximum fury.

The Calcutta cyclone of 1864 crossed the coastline near Contai moving in direction nearly at right angles to the coast. There was an enormous accumulation of water at the north-west angle of the bay. The storm waves were estimated to have risen 12m high. Loss of human life from drowning was estimated at 50,000 and later 30,000 more died of diseases as a result of the inundation.

In the Bakerganj cyclone of 1876, the storm moved across the Bay towards the north-east, passing through the eastern shore of Bakerganj and extending to Chittagong area. An enormous stormwave was driven over the islands and lowlands surrounding the mouth of river Meghna. There was an unusually high tide, followed shortly by a storm wave. The forceful pressure of the advancing tidal wave prevented the tidal and river water from flowing. It overpowered the down-flowing waters and rushed with tremendous force over the islands and low-lying coastal areas and covered them with water to a depth of 5 to 12 m. It was estimated that more than two lakh people died due to drowning and diseases.

A severe cyclonic storm which struck West Bengal in October 1942 was one of the most destructive on record. Though the centre (eye) of the storm did not pass through Calcutta, the city experienced gales (112 km. p.h.) throughout the night. Widespread and very heavy rains fell in south-west Bengal. Associated with this storm, a 'tidal bore' inundated an area of more than 600 square km. with 5 m. deep water. A heavy loss of life and property was reported in the districts

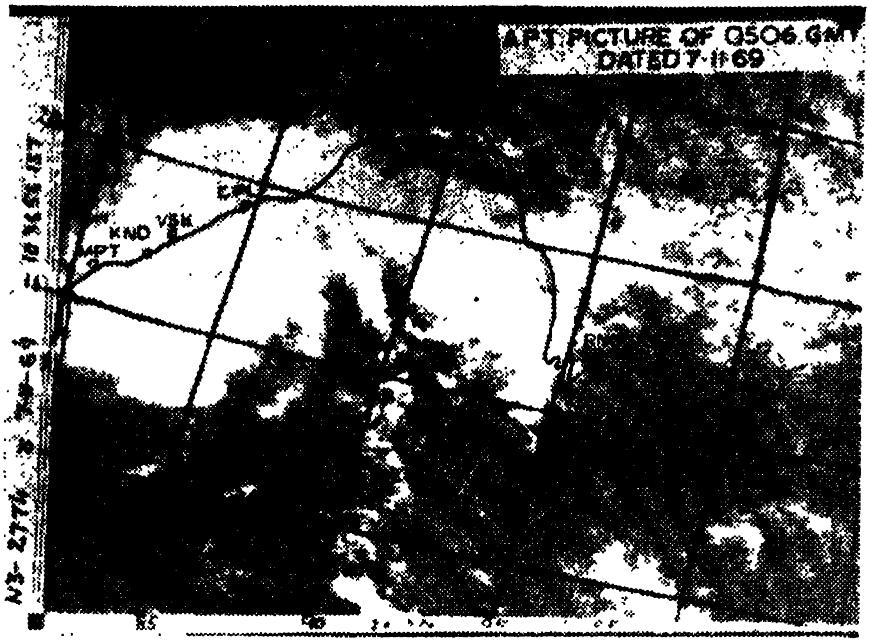


Fig. 3. Satellite photo of a cyclonic storm

of Midnapore and 24 parganas. About 50,000 people and more than 75,000 cattle heads perished.

In the Bangla Desh cyclone of November, 1970, a depression was formed in the Bay about 800 km east of Madras. It became a severe cyclonic storm by November 10. Moving in north-easterly direction it reached about 300 km south of Calcutta on the morning of 12th. Suddenly it took a sliding easterly course and crossed the Chittagong area of Bangla Desh in the early hours of 13th November. Fortunately, the coastal areas of India narrowly escaped its fury.

The typhoons of the south-west Pacific and hurricanes of the Carribean and Gulf of Mexico are usually more severe and therefore inflict greater damage over these coastal areas. The havoc is caused individually and collectively by the high winds, heavy rains and the abrupt inundation by storm waves.

Although it has been proved that the tropical cyclone is the most dangerous killer agent of nature, no successful attempt has so far been made to prevent it. However, timely precautionary measures prevent loss of life and reduce damage to property. With the help of meteorological instruments and know-how, remarkable progress has been made towards detection of cyclonic storms and forecasting their intensity and movement. The India Meteorological Department has set up powerful radars at the Storm Warning Centres at Calcutta, Visakhapatnam, Madras and Bombay. Recently, more scientific approaches have been made with the aid of electronic computers for forecasting the movement of cyclonic storms. When a cyclone comes within the detection range of a coastal radar (present range is 400 km), it is possible to keep an eye on it and warn the people of the area in due time. Now-a-days such warnings can be issued 15 to 25 hours ahead.

How Mosquitoes Find Their Host

ASHIS KUMAR MAITY

Heat, moisture, carbon dioxide, odours and visual stimuli act on the complex sense organs of mosquitoes and guide them to the source of their meals with unerring precision

MOSQUITOES make their presence most conspicuous by their ceaseless search for hosts and attacking them persistently almost at all possible places and through all seasons of the year. Females of the species feed on meals of fresh blood of human beings, his domestic animals, and also of wild animals and birds. They know how to find and reach their hosts by defying the protective measures. They are apparently capable of slipping inside mosquito-curtains, dodging strong blasts of air from electric fans and travelling as co-passengers with human beings in running trains and road vehicles.

A phenomenon familiar to all of us is the variation in mosquito activity during hours of the day. Most species are active during a certain part of the day or night, or at the twilight hours of dusk and dawn; although mosquitoes may bite at almost any hour of the day if disturbed. Among the common mosquitoes of India, those belonging to the genus *Aedes* are the day-biting type, while those belonging to the *Anopheles* and *Culex* genera are the night-biting types.

How does a mosquito find its host? The response of mosquitoes to their hosts is stimulated in three steps: (1) activation (i.e., a change which induces mosquitoes to respond more strongly to orientating stimuli), (2) orientation, and (3) alighting. Extensive experiments support what was long suspected—that the factors that play key roles in the location and recognition of the host by the mosquitoes are the natural by-products of the host's metabolism such as heat, moisture, carbon dioxide and odour, together with various visual factors.

Laboratory investigations

Laboratory investigations of mosquito behaviour have been carried out by placing sources of stimuli within the cage, or by allowing convection currents to rise through the perforated floor of a cage containing the mosquitoes. But frequently, a rather elaborate set up called an "olfactometer" has been employed; In it a current of air is made to carry the particular factor under investigation (called the test air-stream) into a cage containing the mosquitoes, and a control air-stream (without the factor) is allowed to flow side by side. The responses of the mosquitoes to these two air-streams are compared. In the laboratory experiments in which responses to a single stimulus are investigated at a time, it is probable that the responses observed are only a small part of a normally complex behaviour, because under natural conditions the host-seeking behaviour of mosquitoes apparenty consists of a chain of reactions involving successive responses to different stimuli.

Responses to individual factors

Heat. Through laboratory and field experiments it has been proved beyond doubt that the host's body temperature is a very important factor in host search of mosquitoes. It has also been established that attraction is caused by convection currents, and not by the direct rays of heat. The females of several species would respond by orientation and

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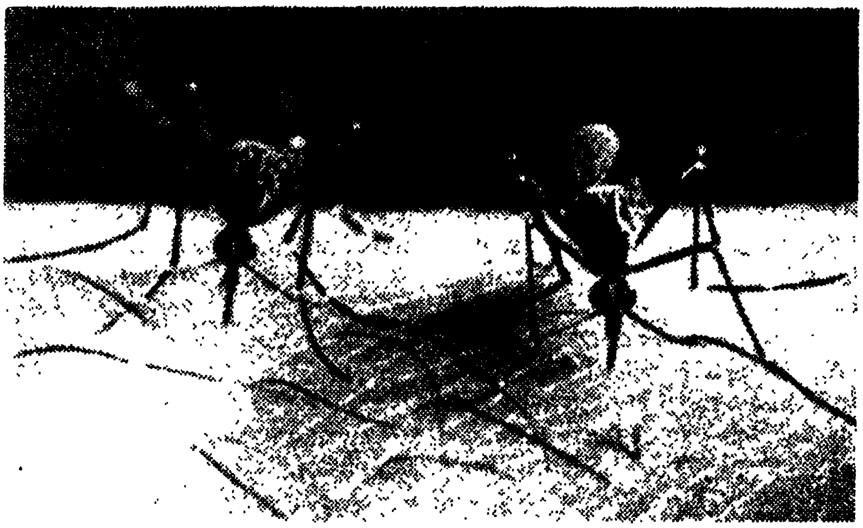
Dr. Maity teaches zoology at Allahabad University.

probing when held in a cage over a warm object. When a thallium bromoiodide filter is interposed between the object and the cage to cut off the convection currents but to allow the infra-red heat radiations to pass through, responses of the mosquitoes would stop immediately. However, such convection currents are effective over short distances only. Caged *Aedes* mosquitoes respond to the convection current (together with the body odours) arising from a man upto 30 cm above his head.

In addition to orientation, heat appears to stimulate alighting and the selection of a particular host preference to others in close proximity. For instance, when the hands of two different persons, differing only in skin temperature, are offered to female *Aedes*, more mosquitoes alight on the warmer hand. If one hand is cooled and then offered with the other hand of the same individual, the mosquitoes again prefer the warmer hand.

Moisture. The behaviour of mosquitoes is clearly affected by water vapour. They orientate towards currents of moist air, showing a strong tendency to alight at the source, if the humidity is not as high as near saturation. *Aedes* mosquitoes would rarely alight on an olfactometer port emitting warm, dry air, whereas they would alight and probe on a port emitting warm, moist air. It is highly probable that moisture is an important part of emanations from natural hosts, acting over short distances. However, water vapour is not invariably attractive; in fact moisture-induced attractiveness is temperature-dependent. For example, at air-temperatures of 17-18°C more *Aedes* mosquitoes would land on a moistened dummy in the field in preference to a dry dummy. At temperatures 8-13°C more of them would prefer the dry dummy. The responses of *Anopheles* mosquitoes are greatly reduced after the relative humidity is raised to 90%. It has also been observed that in case of *Aedes* mosquitoes, the attractiveness is inversely proportional to the transpiration rate. For example, when offered two hands of different individuals of similar surface temperature but with different transpiration rates, at the air-temperature of 26-32 °C and in the air of relative humidity 30-65%, more *Aedes aegypti* would prefer to land on the hand which transpires less moisture.



Aedes aegypti enjoying a hearty meal

Carbon-dioxide. Within about 50% relative humidity (with unheated air), it has been conclusively proved that the emission of 10% CO_2 at the rate of 200 ml per minute (*i.e.*, the normal human exhalation rate) from a source greatly increases the landing rate of various species of *Aedes* mosquitoes. CO_2 emission in human (and animal) breath is thus an important source of attraction of mosquitoes to men. This has been conclusively proved in *Anopheles*. *Anopheles* mosquitoes are relatively inactive in the day-time. An air-stream containing about 4% carbon dioxide would immediately activate them to fly about, they would gather at the source of the CO_2-bearing air-stream, and show incessant searching and probing movements.

Indeed the mere presence of an observer would activate *Aedes aegypti* adults to respond to the convection current of warm, moist air produced thereby. It seems that in combination with heat and moisture CO_2 activates mosquitoes, while the other two factors bring about effective orientation.

Odours: The responses of various species of *Anopheles* and *Aedes* mosquitoes to odours from the host has been clearly demonstrated in olfactometer experiments in which heat, moisture and CO_2 had been carefully eliminated. Some workers believe that odour constitutes the most important factor in host finding in mosquitoes.

Smell acts principally as an activator. It raises the sensitivity of mosquitoes to temperature gradients and also releases a search response, to enable them to ultimately orientate to the host. The likely sources of odour from the host's body are sweat, blood and urine.

It appears that both types, eccrine and apocrine, of human sweat attract mosquitoes. Eccrine sweat is produced all over the body and contains sodium chloride, lactic acid, amino acids, urea and ammonia. Apocrine sweat contains proteins, carbohydrate and ammonia and is largely produced in the axiliary regions and also in the regions around the external genitalia and the anus. The protein fraction of apocrine sweat provides a good medium for bacterial growth. The characteristic smell of the human adult is due to the bacterial decomposition products of this sweat. Eccrine sweat, on the other hand, is odourless, although a mild odour may develop as a result of bacterial action on skin debris. Variations in the odour given off by different individuals may be due to chemical differences in apocrine sweat or due to differences in their bacterial flora, or due to both. The precise chemical factors causing attraction are not fully known, but amino acids, diphenols and steroids have been implicated as the possible attracting compounds.

There is evidence to indicate that free whole-blood of various animals attract mosquitoes, although the removal of CO_2 reduces by half the stimulating power of the blood. Female *Aedes aegypti* mosquitoes have also been experimentally found to be attracted to human urine in certain dilutions.

In their relative attractiveness to mosquitoes, human beings differ markedly from one another. If *Aedes* mosquitoes are allowed to choose between streams of warm, moist air passing over the hands or the armpits of two individuals, they frequently show a strong preference for air stream from a particular individual. In experiments performed with four men and three women, tested in pairs, it was observed that individual attractiveness varies from one experiment to another, and that an individual of the same sex may or may not be significantly more attractive than the other, but men are almost always much more attractive than women !

Since certain host-emanations have been found to be attractive to mosquitoes in extremely minute quantities (say, for example, 41 molecules per c.c. of air), it is probable that host odours carried by wind may sometimes be sufficient to activate mosquitoes at distances of two km or even more. This appears quite likely, because sex-attractants of certain insects have been found to be active at distances of several km from their source.

Visual factors

Experiments carried out on *Aedes* mosquitoes with anaesthetized or active mouse hosts contained in transparent but either air-tight or perforated boxes have revealed that, in case of a stationary host, air-borne factors are more important than visual factors; but when the host moves, visual factors are the more powerful. The way in which host-seeking mosquitoes are stimulated by the effect of movement has been studied. It has been revealed that, as with many other insects, objects with greater contour are preferred by the mosquitoes.

With human beings in general, the attractiveness of a cloth as an alighting surface is inversely proportional to its brightness (as measured by the amount of light reflected) within the colour range blue, green, yellow and orange, (i.e., between the wavelengths 4750Å-6250Å). However, no such clear correlation can be obtained when the reflection of the entire visible spectrum, together with ultraviolet light (i.e., between 3000Å-7000Å) is considered. Nevertheless, dark shades are clearly more attractive to mosquitoes, and it is quite likely that bright shades are actively repellent. As is to be expected on this basis, skin colour does affect the responses of mosquitoes. Experiments with *Aedes aegypti* show that they prefer darker skin colours as they alight on darker skins in significantly greater numbers.

Certain observations suggest that the presence of some mosquitoes already on the skin of a host makes it more attractive to other mosquitoes hovering nearby. It is possible that the hovering mosquitoes show a direct response to the other mosquitoes already on the skin of the host.

Field observations

It is generally accepted that mosquitoes locate human settlements or animal sheds from considerable distances by an active process. They do not arrive simply by chance through random flight. Field observations support the view that mosquitoes downwind of distant hosts can reach the hosts through flying into the wind after being activated by windborne factors. The windborne factors which probably activate mosquitoes to fly upwind are heat, moisture, CO_2 and body odour, although the maximum distances at which they can activate the mosquitoes are not yet known.

Since there is evidence that odour is important in attracting mosquitoes from a distance, it raises the pertinent question—do unclean habits help in attracting more mosquitoes? There are field observations that prove that this indeed is the case. In an experiment it was found that huts containing five unwashed children were much more attractive to species of *Anopheles* and *Mansonia* mosquitoes than huts containing five washed children. Two species of *Anopheles* mosquitoes are attracted to huts containing dirty clothes in much larger numbers than to empty huts.

A curious behaviour of three species of *Anopheles* mosquitoes (of the West Indies and West Africa) reported is that they are attracted in large numbers to human adults, but much less to children, particularly infants. In case of *Aedes aegypti* also, it has been established that the attractiveness to human babies is very low, but by the end of the first year of the baby's life attractiveness rises to a higher level. It rises further as the babies (particularly the males) reach puberty.

For day-biting mosquitoes (viz., *Aedes, Eretmapodites*, etc.) in the field the sight of the host is an important component of host-finding. An easily visible standing bait attracts more mosquitoes than one lying down, whereas a bait which moves slightly is more attractive than a motionless one.

Sense organs

Intensive studies have been carried out on *Aedes aegypti* and on certain species of *Anopheles* mosquitoes by systematic amputation of the various sense-organs in order to find out the precise role that these organs might play in host-finding in mosquitoes. Experimental evidence indicates that in female mosquitoes, apart from sight, all the visible sensilla of the "feelers" or antennae together with the sensilla located in the maxillary palps are the probable receptors of airborne stimuli such as odour, CO_2, temperature and water vapour. Sight is undoubtedly of very great importance in day-biting mosquitoes. In addition to these sense organs, the "Johnston's organ" (situated at the base of each antenna) also helps indirectly in host-finding by controlling the mosquitoe's equilibrium during flight.

Conclusion

In some day-biting mosquitoes the sight of the host is the most important stimulus, leading the mosquito directly to the host. In night-biting mosquitoes, and probably in day-biting types as well, windborne odours and CO_2 probably provide the initial stimulus. The mosquitoes respond to them by flying into the wind, and therefore towards the host, maintaining their orientation into the wind by visual means. When the females arrive in the vicinity of the host, they are stimulated by other directional stimuli, *viz.*, gradients of heat and moisture, which lead them to alight on the host. Further stimuli from the host lead them to the consummatory act of gorging. Host-seeking behaviour in mosquitoes, therefore, consists of a chain of reactions, each reaction triggered off by a different stimulus from the host, ending in alighting and gorging.

Further reading

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READERS PLEASE NOTE

In view of the all round increase in cost of paper and printing during the recent months, it has been decided to revise the price of *Science Reporter* with effect from July, 1974. The new rates will be: Re. 1.00 per copy and Rs. 10.00 for annual subscription.

GROWING PLANTS In Test Tubes

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S. S. BHOJWANI

INNUMERABLE cells which constitute the body of a flowering plant are derived from a single-celled zygote (fertilized egg) by equational divisions. It is amazing how diverse—structurally as well as functionally—can the derivatives of the same cell be. Some cells form the green photosynthetic tissue in leaves, others function as the conducting channels to transport water from the root to various parts of the tree, and still others become part of the gorgeous petals of its flowers. What is intriguing in this regard is whether this diversity is achieved by permanent alteration in the genetic composition of the cells or it is the result of mere adaptation of the cells to perform a particular function in the plant body without affecting their genetic make-up.

A similar question was asked by the great German plant physiologist, G. Haberlandt, as early as 1902. He tried to answer this question by isolating leaf cells and growing them in nutrient medium to see if each one of them retained the ability to behave like a zygote and could give rise to a complete plant. Technically speaking, Haberlandt wanted to test the totipotency of the cells. Faced with the problem of poor techniques available at that time he could not induce divisions in the isolated cells. His idea was, however, conceived by subsequent workers. The pioneering works of P.R. White (U.S.A.), R.J. Gautheret and P. Nobecourt (France) helped found the discipline of *in vitro* culture in the early thirties by successfully growing isolated plant cells. During the past 20 years enormous efforts have gone into refinement of the techniques, and plant physiologists have established that an isolated cell from either root, stem, leaf, or any other part of the plant body, if provided with suitable conditions, would develop into a new plant exactly like the stock plant from which the cell had been isolated.

Requirements and conditions

Broadly speaking the term "*In vitro* culture" means growing isolated cells, tissues, or organs, or whole plants on nutrient medium under aseptic conditions, generally in glass tubes or flasks. There are three important technological aspects of this technique, *viz.*, (1) nutrient medium, (2) aseptic conditions, and (3) aeration.

Plant cells, tissues, and organs can be excised and grown into complete plants on nutrient medium in glass vials. This technique can be used for rapid multiplication of selected strains of plants of economic importance and also for obtaining healthy plants from virus infected stocks

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Nutrient medium. Many receipes of nutrient medium have been developed from time to time. Every tissue has its special requirements and these need to be worked out when starting the work. However, some common ingredients of the medium are inorganic salts of major and minor elements, and vitamins. Sucrose is employed as the source of energy. Besides this, some growth regulators such as auxins and cytokinins may also be added to the medium either alone or in different combinations. Natural plant extracts such as coconut milk, corn milk, and various fruit juices have also been found to support good growth of some tissues. All the constituents are dissolved in distilled water. If necessary, the medium is solidified with 0.8% agar-agar. pH of the medium is adjusted around 5.8 (slightly acidic). Equal quantities of the medium are then dispensed in culture vials which are usually glass tubes or flasks. The vials are finally plugged with non-absorbent cotton wrapped in cheese cloth. Such a closure allows exchange of gases but does not permit the entry of microorganisms.

Aseptic conditions. The culture medium of the composition described above, especially when it contains sugar, would support a luxurient growth of the micro-organisms like bacteria and fungi. If they reach the medium, the micro-organisms grow faster than the tissue and finally kill it. It is, therefore, extremely important to maintain completely aseptic environment inside the culture vial. The micro-organisms present in the medium are destroyed by autoclaving it in what can be regarded as a large cooker. The medium is completely sterilized by maintaining it at 120° C for 15 minutes.

Infection may also be carried by the tissue which is to be cultured. Therefore, the plant material from which the tissue is to be excised is disinfected by first washing it with a detergent and then rinsing it in a saturated chlorine water for 15 minutes. If the material is fairly hard, as are some seeds and fruits, it may be surface-sterilized by rinsing in alcohol. Precaution is also to be taken to prevent the entry of any micro-organisms while transferring the tissue to the medium (inoculation). For this reason all operations from surface sterilization of the tissue to inoculation are done under aseptic conditions. The chamber used for inoculation is sterilized by ultraviolet light (which should be put off before entering) or by constant flow of filter-sterilized air. The table inside the chamber is swabbed with alcohol before use. After the material has been treated with chlorine water for adequate period, it is repeatedly washed with sterile distilled water to remove every trace of chlorine water. Now the neck of the culture vial is flamed and in quick succession the closure of the vial is removed, the tissue transferred on to the medium and the closure replaced. It is equally important to sterilize the instruments used for inoculation by dipping in alcohol and flaming.

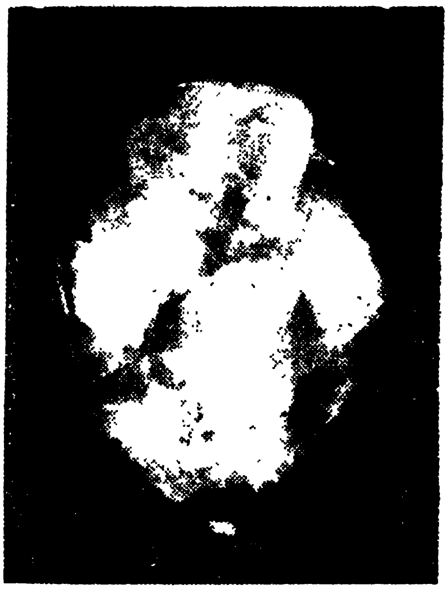

Fig. 1. A profusely growing callus in a nutrient medium

Aeration of the tissue. The methodology should also account for proper aeration of the tissue. If it is growing on the surface of solid medium it acquires enough aeration without any special device. However, if liquid medium is employed the tissue would get submerged. In such cases some special methods are adopted to aerate the tissue. One possibility is to use filter paper bridge whose two legs remain dipping in the medium and the horizontal part carrying the tissue is raised above the level of the medium. Agitation of the medium by passing through it filter-sterilized air also serves the purpose. More commonly, however, aeration is provided by shaking the flasks or tubes on a rotary or horizontal shaker. Besides supplying oxygen to the tissue, shaking of the medium also brings about dissociation of the tissue into single cells and small cell-clumps.

Cultures are usually maintained in 16 hr. light at a temperature of 25° C and around 50% relative humidity.

Cultures may be initiated with meristems which include actively dividing cells, such as shoot apices, or highly differentiated cells such as leaf cells. Depending on the composition of the medium, a meristem may follow either of the two modes of development: (1) it may continue to grow in an organised fashion and directly give rise to a plantlet, or (2) proliferate into an amorphous mass of tissue, the callus (Fig. 1). The callus in many cases can be multiplied indefinitely and can also be induced to form plants when required (Fig. 2). The second mode of development is generally employed in plant propagation.

Rapid multiplication of plants

Each fruit of an orchid plant develops several thousand tiny seeds

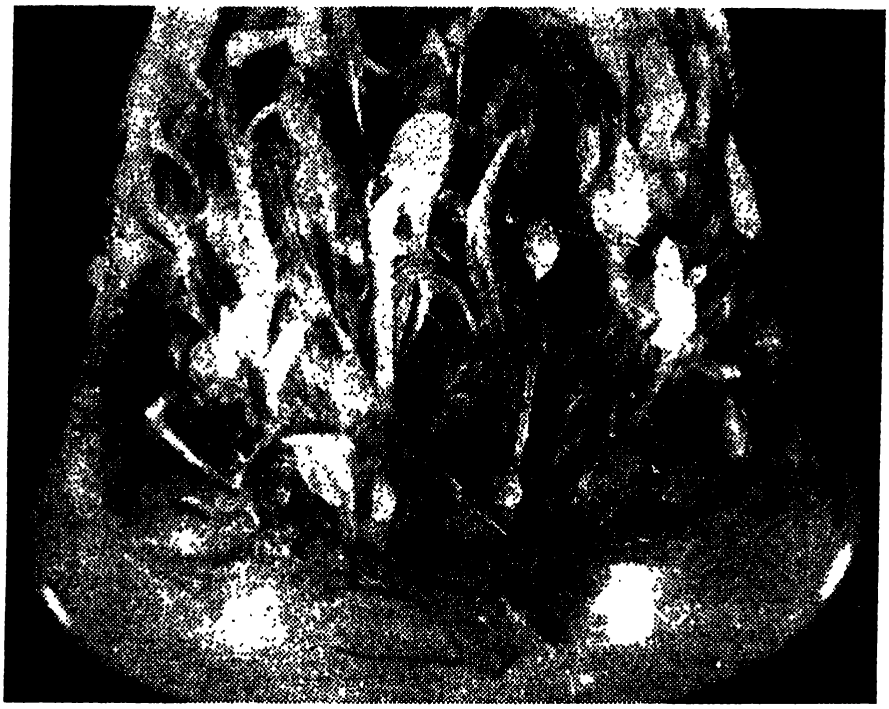

Fig. 2. A flask full of plants arising from a portion of the callus

which are peculiar in structure and the mode of germination. Commonly, a seed contains a well differentiated embryo bearing an embryonic root (*root*) and an embryonic shoot (*plumule*) at opposite ends. In orchid seeds, however, the embryo is a spherical mass of tissue lacking both radicle and plumule (Fig. 3-I). In nature these seeds germinate only in association with a proper fungus or else they perish. As a result, numerous seeds are lost. Nearly half a century ago L. Knudson (U.S.A.) demonstrated how conveniently the seeds of orchids can be grown *in vitro* without the association of a fungus. Since then *in vitro* culture of seeds is routinely employed for orchid propagation. Big orchid growers have their own laboratories for this purpose.

In cultured seeds, the embryo enlarges to form a spherule-like structure, the protocorm, which is initially white but gradually develops green pigment. After attaining a size of the order of 1.5 mm. it forms the first leaves followed by roots. The plantlets are ready for transplantation after three to four months. Seed culture of orchids however has one major limitation. Most of the commercial varieties of orchids are complex hybrids and do not produce seeds. Those which do show a great variation in the progeny. To obtain a homogenous population identical to the selected individuals, breeders practice vegetative propagation (cloning). Unfortunately, vegetative multiplication in orchids under field conditions is generally slow and the yield too low for extensive commercial use.

While working on *in vitro* culture of shoot apices of orchids with an entirely different purpose, Professor G. Morel (France) in 1964 made a significant observation which has revolutionized orchid propagation. The shoot apices grown in nutrient medium, instead of continuing stem-like development, rounded-off to form protocorm as does the embryo during germination. Moreover, each apice produced a clump of about half-a-dozen protocorms (Fig. 3-II) each of which further developed into a plantlet (Fig. 3-III). However, if this clump, before forming plants, was cut into four small portions and planted on fresh medium, each one grew and budded-off four to eight protocorms within a month's time. By monthly transfers and consecutive sectioning Morel could build up a large stock of one type in relatively short time. According to his estimates, if each protocorm gives only four new ones each month by this process it would be possible to obtain more than four million plants per year from a single shoot tip.

The method developed by Morel has been refined further. The shoot apices are grown in liquid medium which is constantly agitated on a shaking machine. In this process the new protocorms continue to bud-off and break down in the medium. When the shaking is stopped each one of them forms a plantlet. In this way the mechanical cutting of the protocorm is avoided.

The exciting breakthrough in the orchid growing industry by the introduction of this technique has now caught the imagination of many horticulturists. The technique is being tried to increase the commercial feasibility of multiplying and maintaining pathogen-free stocks of horticultural plants and also to increase the rate at which planting stocks of new varieties would be built up. Some of the horticultural plants which have shown promising results include carnations, chrysanthemums, asparagus, freesias, etc. Recently, W.P. Hackett (U.S.A.) has shown that by culturing leaf scales of lilies (*Lilium longiflorum*) *in vitro* the rate of multiplication can be doubled from that obtained under most favourable environmental conditions.

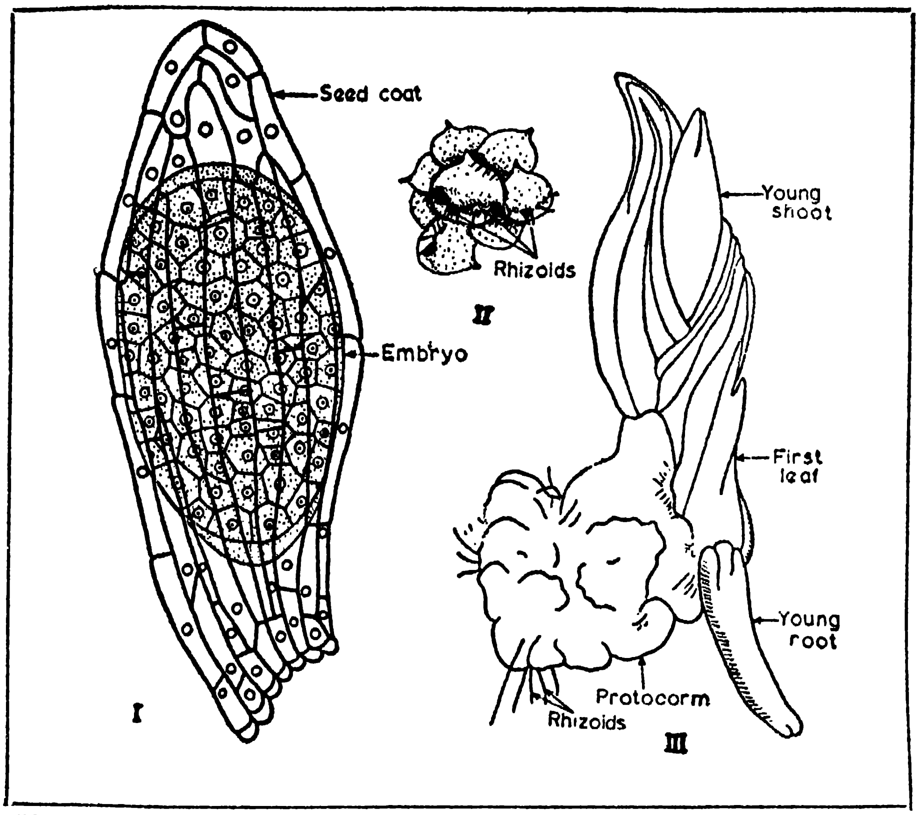

Fig. 3-I. Mature seed of an orchid. Spherical embryo can be seen through the transparent seed coat; II- A cluster of protocorms budded off from a single protocorm; III- An orchid seedling raised from cultured protocorm

Plant improvement

When a breeder has obtained a desirable genetic variant through the tedious methods available to him, he is keen to obtain several replicas of it within a short period so as to hasten its commercial exploitation. Moreover, if there are only a few individuals of a particular strain the chances of its becoming extinct are very high. The technique of *in vitro* culture has a great potential in this regard.

Plant tissues, vegetative or reproductive, can be conveniently grown in cultures. By trial and error a medium can be devised to obtain callus from the tissue. By regular subculture of the callus in a fresh medium a large stock of the tissue can be built up like the protocorms of orchids. Part of this tissue may be employed for multiplying the stock, and the remaining subjected to further treatments for plantlet formation. In this way the selected strain can be multiplied at a faster rate and at the same time a bank of disease-free tissue maintained indefinitely. At experimental level feasibility of this approach has been demonstrated in carrot, cauliflower, tobacco, aspen, etc. Serious attempts are being made in many laboratories to employ this technique for the multiplication of such economically important plants as palms, pines and cotton.

In plant breeding programmes all desirable crosses are not successful. Often it happens that the hybrid embryo aborts at an early stage and hence viable seeds are not produced. By removing young embryos from the seed and growing them in a more hospitable environment inside the culture vials it is possible to raise a complete hybrid plant. This method of "premature birth" has proved valuable in obtaining hybrids of fruit trees such as peach, apricot, cherry and plum.

The latest trend in plant tissue culture in relation to agriculture is the production of true breeding plants through anther culture and raising parasexual hybrids through the culture of fused isolated protoplasts.

Production of true breeding plants

Commonly a plant has two sets of chromosomes in each of its cells and is called diploid. Each chromosome of a set is characteristic and has its homologous chromosome in the other set. So, each chromosome is represented twice in the cells of a diploid plant. Homologous chromosomes carry genes controlling same traits. For example, both may carry genes for height of the plant but it is possible that one of them is for tallness and the other is for dwarfness. When the homologous chromosomes are not identical the plant is called *heterozygous* and its progeny is not uniform. On the other hand, if genes on homologous chromosomes are identical the plant is referred to as *homozygous* or true breeding and produces a homogenous population. When a selected outstanding variety is being introduced for commercial exploitation heterozygosity is disadvantageous. The conventional method of obtaining homozygous plants from a heterozygous one is to self-pollinate it generation after generation until a generation of completely homogenous population is achieved. An alternative to this lengthy approach has been to look for natural haploids (having only one set of chromosomes) from which homozygous diploids can be obtained by the methods of colchicine treatment. Unfortunately, the natural occurrence of haploids is almost insignificant. Therefore, breeders have always felt the need of a more efficient method to obtain haploids. The *in vitro* culture technique has now made it possible to obtain large number of haploids at will.

Pollen grains (male gametophyte) of a diploid plant are as a rule haploid and form the male gametes. In nature the latter fuse with the haploid female gamete and give rise to a diploid plant. If anthers containing haploid pollen are cultured at the right stage before the gametes are formed on a proper nutrient medium, the mode of pollen development can be altered. Instead of forming gametes it can be made to develop into a haploid plant (phenomenon described as *androgenesis*). Using this technique a large number of haploid plants—tobacco, tomato, potato, wheat, rice, barley, etc.—have been obtained. Many agricultural research stations round the world have established laboratories for anther culture. This technique will no doubt lead to exciting possibilities in crop improvement.

Somatic hybridization

Unlike animal cells, plant cells are invariably enclosed in a rigid cellulose-rich wall which does not allow fusion of two cells. However, the cells from which the wall has been removed (protoplasts) either mechanically or enzymatically fuse quite readily following short-term treatment with sodium nitrate. Fusion can be brought about between the protoplasts of different varieties, species, or even genera. Theoretically, if the nuclei of the fused protoplasts upon culture *in vitro* are able to fuse and regenerate a common wall, a true hybrid cell may be formed. This hybrid cell could be induced to divide and give rise to a hybrid plant. The technique is far from perfection but preliminary studies are quite encouraging. Should this be possible, we shall have some rare hybrids which have not been produced so far due to sexual incompatibility.

Healthy stocks

Unlike animals, once a plant is infected with virus it remains so throughout its life time. Most of the perennial horticultural plants are propagated vegetatively by layering, cutting, grafting, etc. The chief drawback of this method is that when stock plant gets infected the entire population raised from it carries the infection. Thermotherapy coupled with meristem culture has proved very useful in plant industry for eliminating viruses from infected plant tissues. In the former, the movement and multiplication of some viruses in plant body is checked by continuous exposure of the plant to temperature of the order of 37° C. When a plant is growing at this temperature the growing tip gradually becomes virus-free. Such virus-free meristem can be excised and grown *in vitro* to obtain complete plants. Once a healthy individual is recovered, it can be vegetatively multiplied either in cultures or in pots under strict hygenic conditions.

In the foregoing discussion an attempt has been made to introduce the technique of *in vitro* culture of plant tissue and some of its potentials in the field of plant propagation. Whereas a fair degree of success has been achieved with horticultural herbs and shrubs, progress with large trees has not been satisfactory. Nevertheless, forest departments all over the world are optimistically trying to use the method for quick multiplication of superior stocks of forest trees. *In vitro* culture technique may also be used to send plants from one country to the other under desease-free condition. This will greatly simplify plant quarantines.

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An Introduction To DIRADICALS

SUKUMAR MAITI

Diradicals are a group of reactive chemical intermediates involved in organic reactions

THE name diradical or biradical is an abbreviation of 'double radical' indicating a species which contains two 'odd electrons'. These unpaired electrons are so widely separated or shielded in space that there exists little interaction between them. Each odd electron constitutes a radical centre in a diradical which is, so to say, "free" in its behaviour, independent of the other radical site. Both these radical centres have in general similar energy and are therefore equally reactive. A diradical is therefore a species which has two radical sites that can effectively behave as almost independent and equally reactive entities in the environment of other molecules. The ideal examples of diradicals are bisgalvinoxyl (I) and tetrachloro derivative of Chichibabin's hydrocarbon (II) in which the two odd electrons are pushed very far away and sterically shielded so that there is practically no interaction left between them.

Singlet and triplet diradicals

In most diradicals the odd electrons are neither so widely located nor so completely sterically hindered. In such molecules the two radical centres interact and the magnitude of the electronic interaction depends on the configuration and geometry of the molecule.

Each odd electron can be considered as a small magnet having its own magnetic moment—a property better known in chemistry as the spin of the electron. If the interaction between the odd electrons in a diradical is strong, the spins of the electrons may be paired, i.e., opposite or antiparallel to each other. Such species with paired spins is called a *singlet*. If the electronic interaction is weak, the spins of the odd electrons may not be paired and may remain parallel to each other. Such a state is called a triplet diradical or simply a *triplet*. Oxygen molecule (III) is a triplet while *o*-dihydrobenzene (IV) is a singlet. (The arrows represent the odd electrons and the arrowheads indicate their spins.)

Singlet molecules having paired spins are diamagnetic and the triplets with parallel spins are paramagnetic. So they can be characterized by their magnetic property.

The diradical character in a molecule is a function of interaction between its two radical sites. The greater the interaction between its two odd electrons the lesser would be the diradical character. That is why triplets behave more as a diradical than singlets do. With gradual increase in the electronic interaction the radical property in a diradical is changed into covalent bonding characteristics and eventually it acquires ionic character. Singlets, in general, posses higher energy than the corresponding triplets. However, both singlets and triplets are involved as reactive intermediates in many chemical reactions—thermal and photochemical.

Production

When a covalent bond between *A-B* breaks two free radicals are formed. But if a covalent bond in a cyclic molecule ruptures, the two free radical sites are held

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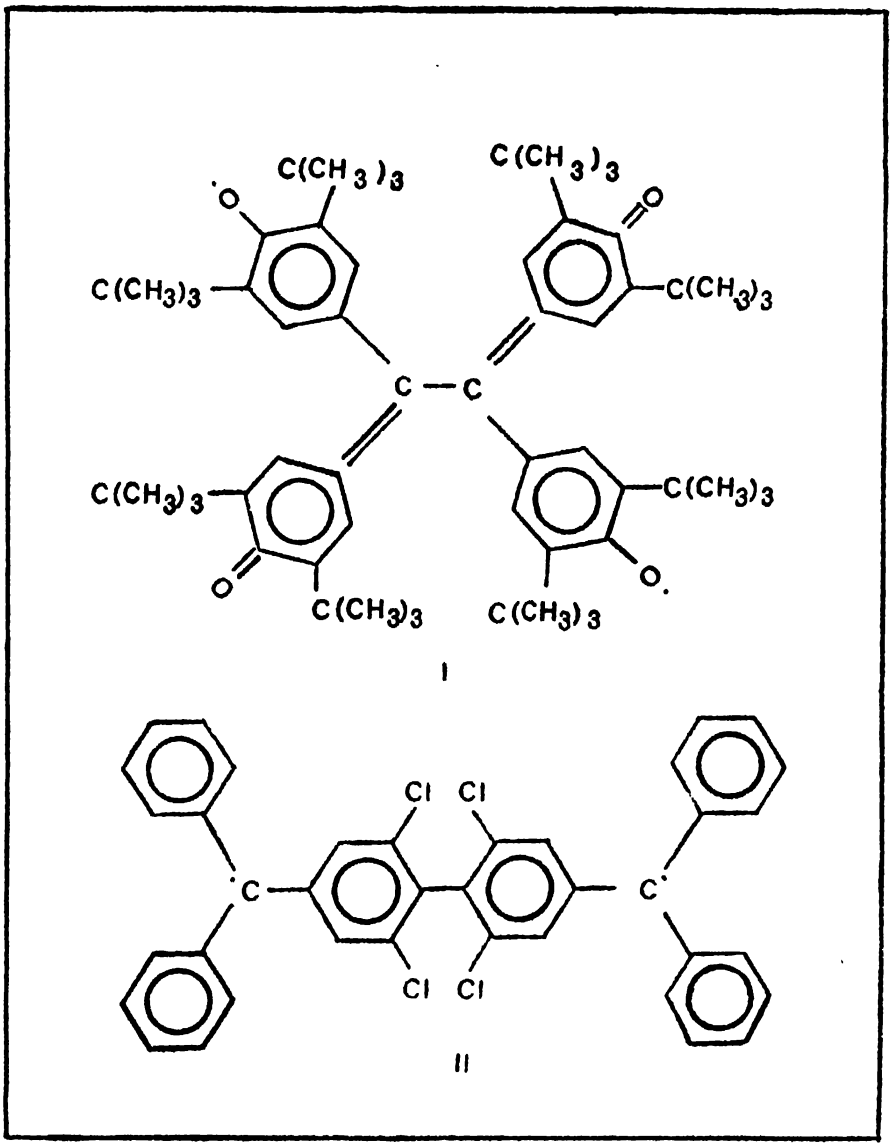

Fig. 1

together to produce a diradical. For example, when one bond of a cyclobutane (V) molecule breaks the tetramethylene diradical (VI) is generated.

Apparently tetramethylene is an ideal example of diradical in which two odd electrons (i.e., radical centres) are insulated against each other by four methylene groups and behave as if they are two free radicals in their chemical as well as spectral properties.

This method of production of diradical is not always feasible due to the coupling of the radical sites which produces back the original compound unless the latter is a highly strained cyclic compound. For instance, trimethylene diradical (VIII) is formed by heating cyclopropane (VII), a highly unstable ring compound. The same trimethylene diradicals may be generated by the photolysis of the cyclic diazopropane (IX).

Although both (VIII) and (X) are trimethylene diradicals, they differ in their spin states: the former is a triplet while the latter is a singlet. Generally, singlet diradicals are produced by direct photolysis and the triplet ones by photosensitization or thermal routes. For instance, singlet methylene (XII) is obtained by direct photolysis of diazomethane (XI), while triplet methylene (XIII) is obtained by the photosensitized decomposition of diazomethane in presence of benzophenone.

Photochemical decomposition of ketene (XIV) under low pressure also yields methylene diradical:

$$\underset{\text{XIV}}{H_2C{=}C{=}O} \xrightarrow{\text{light}} H_2C{:} + CO.$$

One of the general methods of preparing polymethylene diradicals is the photochemical decomposition of cyclic ketones in the gas phase.

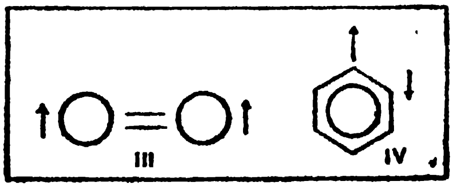

Fig. 2

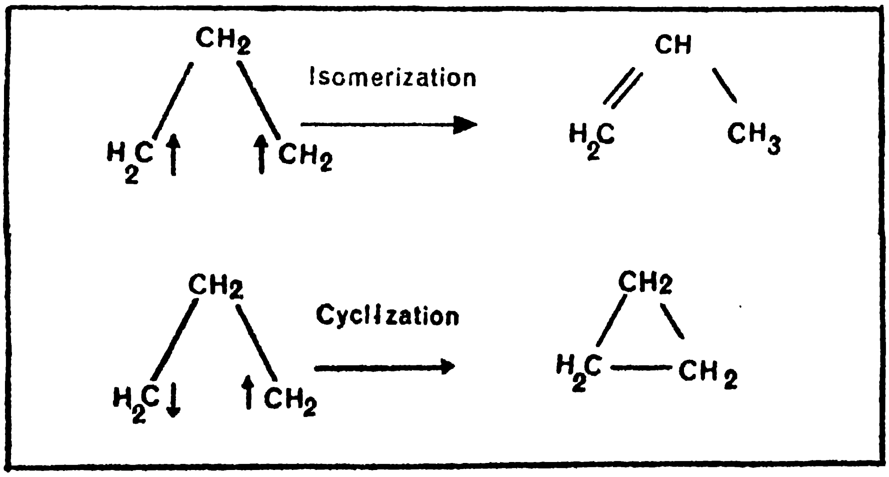

Fig. 3

Another general method is the reaction of sodium vapour with dibromo derivatives of polymethylenes:

$$BrCH_2\text{-}(CH_2)_n\text{-}CH_2Br + 2\,Na \longrightarrow \cdot CH_2\text{-}(CH_2)_n\,CH_2\cdot + 2NaBr$$

Reactivity

The life span of a species is an index of its reactivity. The shorter the life-time the greater will be its reactivity. Like free radicals, many diradicals have also transitory existence. Some diradicals have life-time of the order of 10^{-10} sec. Hence it is difficult to detect such illusive species. Sometimes their existence or generation in the reaction medium has been inferred from the analysis of the stable products. However, not all diradicals are such illusive. For example, diradicals like (I) or (II) are stable in ordinary conditions for almost an indefinite period. The diradical species, in many reactions, appear to be a brief halting station in the journey from reactants to products.

Diradicals obtained from the pyrolysis of small ring hydrocarbons such as cyclopentane may undergo isomerisation or ring closure depending on its spin-state. In triplet diradicals coupling of radical centres is hindered by their parallel spins. So, triplet diradicals generally isomerise to the stable form. For example, triplet trimethylene isomerises to propylene by hydrogen migration. Singlet trimethylene, on the other hand, undergoes radical coupling to form the parent cyclopropane (Fig. 3).

Singlet species is more energetic and, therefore, less discriminating in many of its reactions. For instance, singlet methylene inserts indiscriminately into carbon-hydrogen bonds and adds stereospecifically to double bonds; the initial geometric configuration of the double bond is retained (Fig. 8).

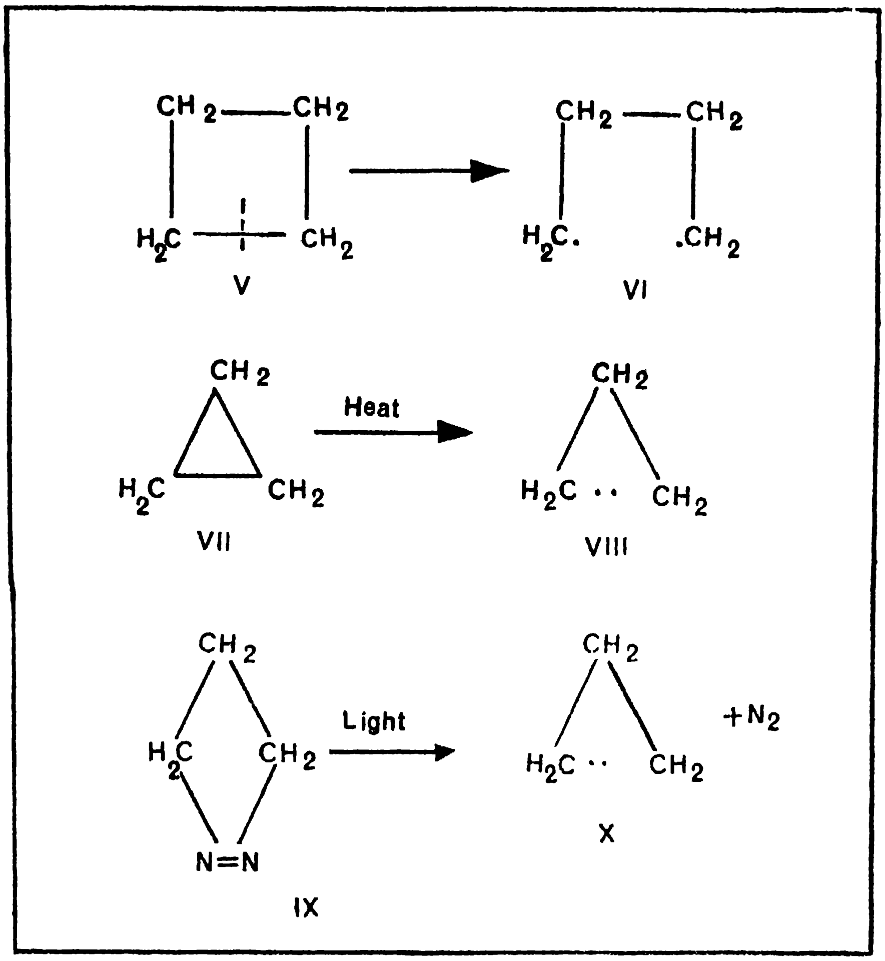

Fig. 4

Triplet methylene does not insert into carbon-hydrogen bond. It adds to olefinic double bond non-stereospecifically and consequently a mixture of *cis* and *trans* isomers is produced.

The triplet methylene addition to olefinic bonds is a two-step process

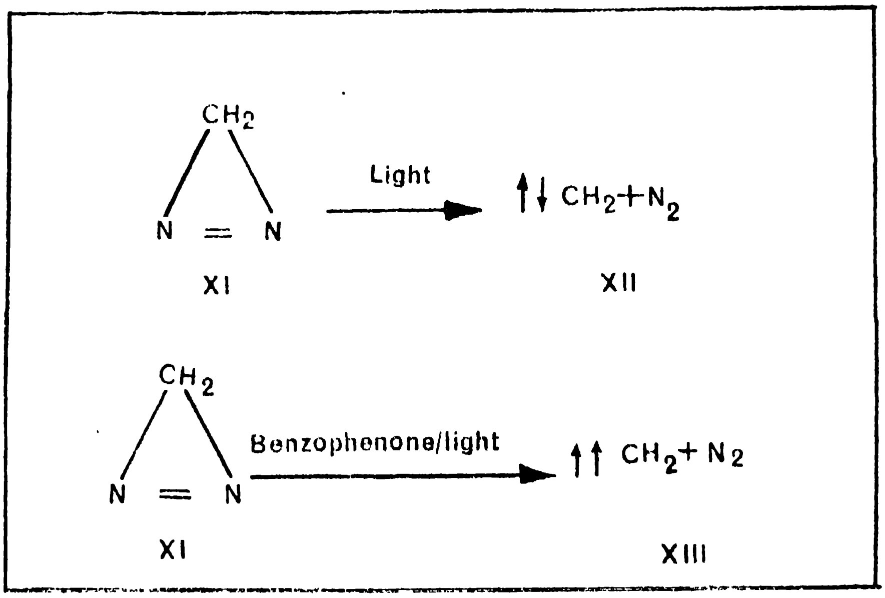

Fig. 5

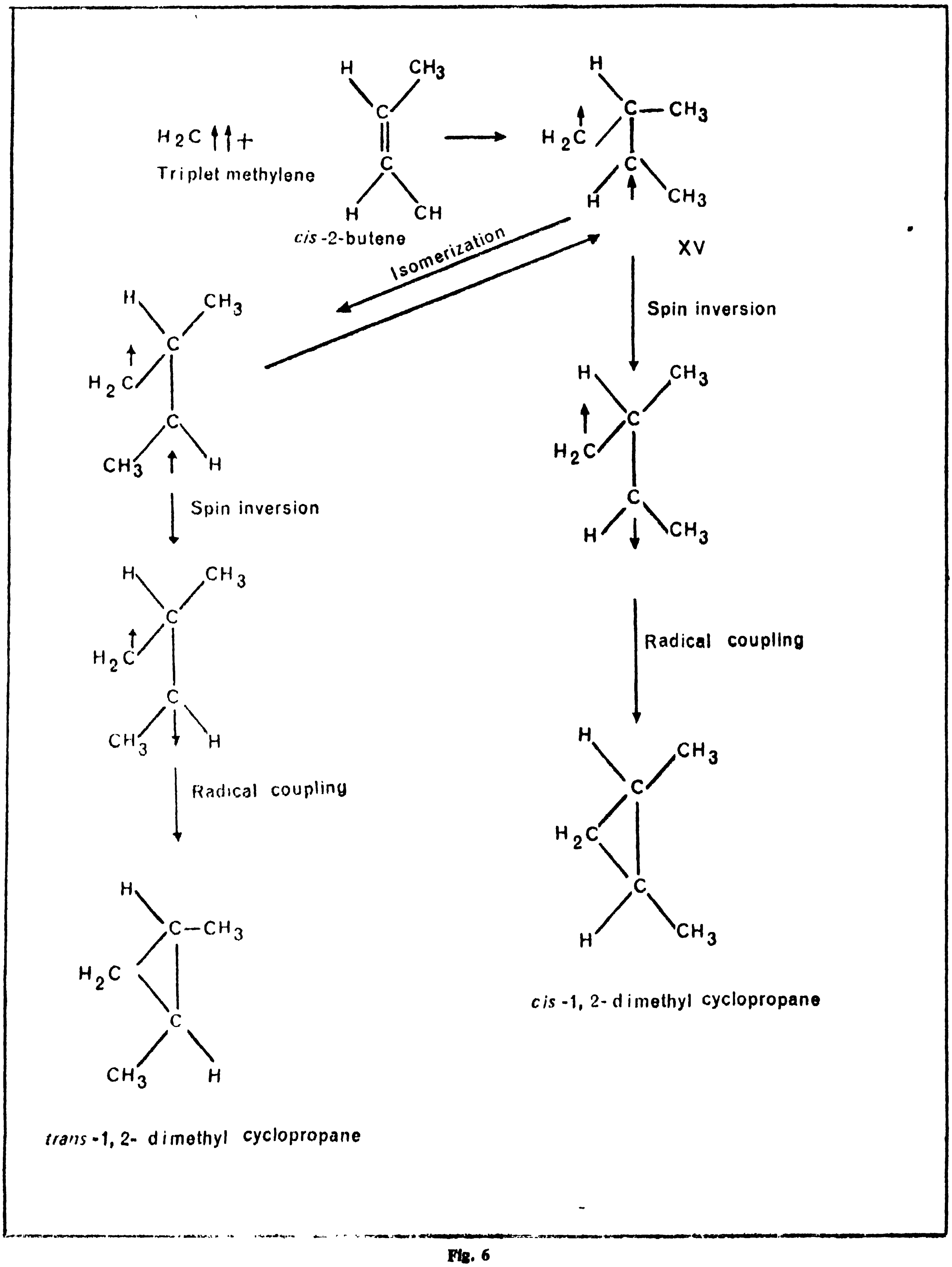
Triplet methylene
cis-2-butene
Isomerization
XV
Spin inversion
Spin inversion
Radical coupling
Radical coupling
trans-1, 2- dimethyl cyclopropane
cis-1, 2- dimethyl cyclopropane

Fig. 6

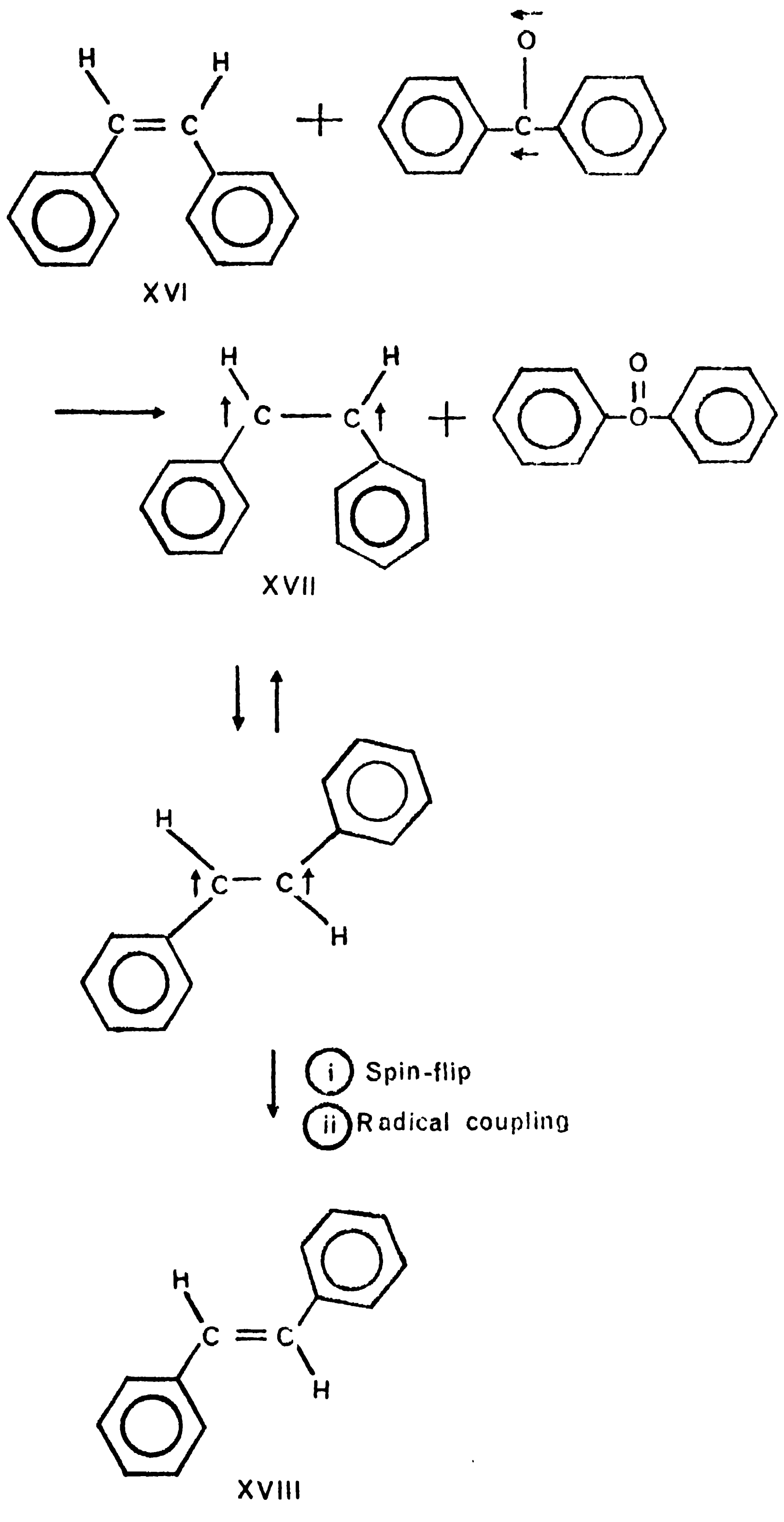

Fig. 7

which involves a diradical intermediate (XV). This diradical requires a spin-flip before ring-closure could take place. The time necessary for this spin-flip is sufficient to equilibriate the two geometrical isomers. On the other hand, singlet methylene addition to double bonds is an one-step process.

It appears from the above reactions as well as from others that triplet species shows more diradical characteristics than the corresponding singlet. Triplet can abstract hydrogen atom readily and can be quenched by molecular oxygen exhibiting free radical behaviour. Singlets, in general, cannot undergo such radical reactions.

The differences in reactivity of singlets and triplets lie more on the energy differences of the two odd electrons than on their odd electronic spin. If the odd electron pairs possess nearly equal energy, both states of triplet and singlet become indistinguishable. They have the same electron distribution and equal diradical character. If the energy difference between these two odd electrons is large, the triplet shows diradical property while singlet would acquire ionic character.

Role of diradicals in chemistry

As stated earlier, diradicals, like free radicals, are also involved in various organic reactions as reactive intermediates. For instance, diradical species are involved in the formation of cyclobutane derivatives from butadiene.

In photochemical reactions excited singlets and triplets are generally produced by photoexcitation of the absorbing molecule. Generally excited singlet species are produced by direct photoexcitation. The triplets are obtained either by interstate crossing of the corresponding excited singlet or by energy transfer in photosensitization. However, triplet diradicals are more

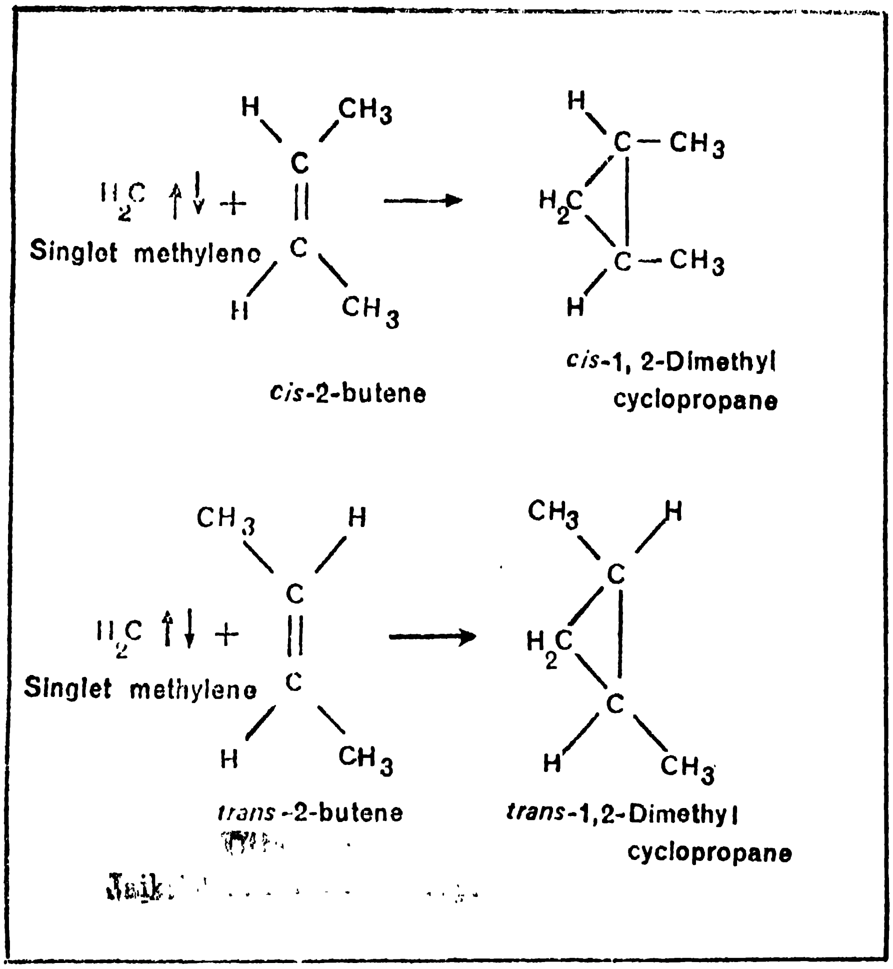
Singlet methylene
cis-2-butene
cis-1, 2-Dimethyl cyclopropane
Singlet methylene
trans-2-butene
trans-1,2-Dimethyl cyclopropane

Fig. 8.

frequently involved as reaction intermediates due to the longer life-time of triplets than that of corresponding singlets.

The general and convenient method of triplet production is by photosensitization using aromatic ketones such as benzophenone, acetophenone, etc., as sensitizer. Such ketones can be readily excited to the singlet states by ordinary visible light (3500 - 4800Å) and the efficiency of intersystem conversion of singlet→triplet is very high, close to unity. Such triplets, like benzophenone triplet, are generally used to sensitize other molecules to generate their triplet state by intermolecular energy transfer.

Cis-trans isomerization is believed to proceed via triplet diradical. For example, *cis*-stilbene (XVI) can be isomerized to *trans*-stilbene (XVIII) via the triplet stilbene (XVII) which may be generated by the intermolecular energy transfer from triplet benzophenone (Fig. 7).

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CAVITATION

And Other Ultrasonic Effects

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C. V. SURYANARAYANA
J. KUPPUSAMI

Cavitation is made use of for the destruction of liquid-borne organisms, in the dispersion of liquid-borne particles, the 'cleaning of metal parts and other hard and soft wares and in the production of emulsions and colloidal suspensions

CAVITATION is a phenomenon observed in boiling water and also in the vicinity of the rotating propeller of a ship in sea. It occurs in those regions of a liquid which are subjected to rapidly alternating pressures of high amplitude. Cavitation is defined as the formation and collapse of cavities in liquids. The cavities are formed by a sudden pressure drop in the liquid which then collapse as the pressure is increased. Cavitation can be produced by anything that causes large local changes in pressure in the liquid, such as ultrasonic waves, or even fast mechanical agitation. In case the medium contains dissolved air or other gases, ultrasonic waves cause large and rapid changes of pressure resulting in the gas coming out of the solution in the form of bubbles. This effect is often called "pseudocavitation" or "gassy cavitation". Genuine cavitation occurs in a thoroughly degassed medium if the pressure changes are sufficient to overcome the tensile strength of the liquid.

The onset of cavitation seems to depend on the presence of nuclei on which the bubbles can form. The nature of these nuclei is not clear. According to one theory, in the case of liquids containing dissolved gases the nuclei are very small solid particles of foreign matter to which the gas bubbles may adhere. According to another theory the nuclei are genuine gas (usually air) bubbles, too small to be seen, whose continued existence in spite of surface tension is due to the protection of a monomolecular organic layer or 'skin'. In the latter view a cavitation intensity threshold is brought out which has been supported by experimental observation. The concept of threshold arises due to the fact that a certain radiation intensity is required to break the skin so that air or other gases may diffuse into the bubble and allow it to grow. The excess acoustic pressure amplitude necessary to produce genuine cavitation increases with the viscosity of the liquid, being about 1.5 atm. for liquids of very low viscosity to about 4 atm. for highly viscous liquids like castor oil (Table I). For a given liquid, the cavitation threshold depends on the frequency—the higher the frequency the higher the threshold intensity. In other words, one can prevent appearance of cavitation

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A typical cavitation burst at 1 Mc/s

even at very high sound intensities if the frequency is kept high enough.

Cavitation bubbles are classified broadly into several forms depending on the way they are formed, e.g., (1) by several small bubbles coalescing together; (2) by degassing of the liquid; (3) by the addition of gas (previously dissolved in the liquid) due to the alternating pressures (gaseous cavitation); or (4) by a decrease in pressure (vaporous type). The last two types are mostly encountered in literature. It is only the vapour-filled bubbles that cause physical erosion and are the basis of many phenomena associated with sound waves that are of interest to electroplaters and cleaners. Gaseous cavitation is more common than the vaporous type.

Mechanism

To bring out a brief picture of the mechanisms of cavitation, we may consider a small region in a liquid through which sound waves are propagated. During the positive half of the pressure cycle the liquid experiences a compression while during the negative half of the cycle it experiences a tensile stress (rarefaction). Thus any bubbles which are present in the liquid will alternately contract and expand. At sufficiently high pressure amplitudes when the initial radius of the bubble is less than a critical value *Ro* as given by the equation,

$$W^2R_o{}^2 - 3\gamma\left(P_o + \frac{2T}{R_o}\right) \Big/ \rho \ldots .(1)$$

the bubble collapses suddenly during compression. In the equation, *W* is angular frequency, *Po* the hydrostatic pressure in the liquid, γ the ratio of the specific heats of the gas contained in the bubble, ρ, the density of the liquid and T, the surface tension at the surface of the bubble. The sudden collapse is known as cavitation. It can result in the release of a comparatively large amount of energy almost instantaneously. The magnitude of the energy released in this process depends on the value of the ratio *Rm*/*Ro* where *Rm* is the radius of the bubble when it has expanded to its maximum size. The ratio depends on the magnitude of the acoustic pressure amplitude which in turn depends on the acoustic intensity. A rigorous mathematical treatment of the growth of the cavity and its subsequent collapse is complicated by the large number of factors involved, like surface tension, liquid compressibility, thermal transfers, gas and vapour transfer and diffusion, time variations in the ambient pressure around the cavities, etc.

Due to the dynamic effects of ultrasonic compressions and rarefactions occurring alternately, gas or air bubbles and cavities can be formed in isolated portions of the liquid. As the liquid expands further (during decompression cycle) the bubble size also increases which in turn leads to a reduction in the pressure inside it. A drop in pressure below the value of the volume rupture strength of the liquid can lead to an unlimited expansion of the bubbles, finally leading to a rupture and formation of a cavity in the liquid. Some of the bubbles which do not attain the critical dimensions are reduced in size during the subsequent compressions, at which stage the growth and contraction processes of the bubbles pulsate with the ultrasonic frequency. Immediately prior to their collapse, the pressure in the bubbles may reach several thousand atmospheres. In other words, at the moment of collapse of the bubbles, powerful hydraulic shocks can occur which can rupture a metal specimen situated in the immediate vicinity and thus bring about several surface effects. One may remember that the shocks repeat *f* times per second, where *f* is the frequency of the ultrasonic waves.

Presence of gases dissolved in a liquid weakens the liquid structure. This means that in liquids there exist definite local places of inhomogeneities in the form of nuclei containing gas. When a rupture occurs it does so at those points where the nuclei are located. Such nuclei therefore facilitate onset of cavitation, even at low ultrasonic intensities. Cavitation can also occur in gas-free liquids (where there is no gas nuclei) when the acoustic pressure amplitude exceeds the hydrostatic pressure in the liquid.

The liquid is in a state of tension for part of the negative half of the pressure cycle. Where this occurs, the forces of cohesion between neighbouring molecules are weakened and

Table 1

Liquid	*η in poise*	*atm.*
Castor oil	6.3	3.9
Whale oil	2.5	8.9
Kerosene	0.04	2.0
Carbon tetrachloride	0.0098	1.75

voids are formed at weak points in the structure of the liquid. These voids grow in size and then collapse in much the same way as gas-filled bubbles. Naturally cavities created in this manner contain only the vapour of the liquid. Tiny dust particles and solid particles having a poor wetting quality can induce cavitation. Similarly, bombarding the liquid with neutrons can induce cavitation.

The amount of energy necessary to cause cavitation can be measured experimentally. Apart from ultrasonics, cavitation may be produced by either thermal, chemical or mechanical action. The effects of ultrasonically induced cavitation have been extensively studied, especially in biology and emulsification. It is used in cleaning operations prior to electroplating. After a liquid has cavitated, it takes sometimes several hours to recover.

The mechanical action of cavitation is the result of the large pressure pulses that arise at the surface of the (immersed) solid body which may be of the order of several thousand atmospheres. Very high pressures can arise not only due to direct shock in the liquid but also upon cavitation bubbles collapsing at some distance away from the surface of the body.

The minimum value of the intensity of sound at which cavitation is initiated can be calculated from the equation,

$$I = \frac{1}{2}\left(\frac{P_a^2}{\rho c}\right)\ldots\ldots(2)$$

where I is given in erg/cm² sec. while P_a is given in dyne/cm² and ρc is the acoustic impedance, ρ being density and c the velocity.

The onset of cavitation is often indicated by a hissing noise called 'cavitation noise'. The threshold of cavitation and also the amount of energy released may be determined from the loss of weight due to erosion of a solid sample placed in the liquid. The quantity of energy released by cavitation is dependent upon kinetics of the growth and collapse of the bubbles. This increases with the surface tension at the bubble interface and decreases with the vapour pressure of the liquid. With comparatively high surface tension, water is a very effective medium for cavitation. Addition of about 10% alcohol results in a considerable increase in vapour pressure but also leads to a decrease in surface tension. However, the added effect due to the rise in vapour pressure is more than off-set by the losses due to the fall in surface tension.

Sonoluminescence

The action of cavitation in a number of liquids has been observed to be accompanied by a luminescent effect. Á weak glow is observed at the air-water interface and in a standing wave system. E.N. Harvey carried out a number of experiments of a qualitative nature particularly concerning the effect of changing the type of gas in solution and the temperature. He observed that luminescence occurs in the presence of dissolved oxygen or nitrogen in the liquid, and that intense luminescence occurs in water at temperatures near the freezing point, which disappears altogether at a temperature above 40° C. Quantitative estimation of the intensity of the luminescence produced in a number of different organic liquids lead to the conclusion that the luminous intensity is proportional to the product of dipole moment and the viscosity of the liquid. It has been established, however, that luminescence does not occur if cavitation is absent. The intensity of luminescence varies with the pressure of air above the liquid, the pressure required to quench the luminescence being dependent directly on the power of ultrasonics. It has been suggested that if the cavitation nuclei carry a free surface charge, the surface may develop high potentials during the collapse of spherical bubbles, and any electrical discharge could be responsible for luminescence. The temperature of the gas in cavitation bubbles may also rise to incandescence and a temperature rise of several thousand degrees may occur before the final stage of the collapse. Chemical reactions caused by cavitation might be responsible for a part of the observed sonoluminescence.

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SCIENCE SPECTRUM

Fermat's last theorem

FERMAT'S contribution to the theory of numbers is unique. He seemed to grasp properties of whole numbers by intuition rather than by reason. His last theorem baffled the wit of all his analytical successors, for no one has yet been able to say whether he was right or wrong. Valuable prizes have been offered for its solution but till to-day, its quiet challenge remains unanswered.

Fermat's last theorem states:

"It is impossible to find three whole numbers x,y,z, such that if n be an integer>2, the equation $x^n+y^n=z^n$ holds".

Fermat then wrote "I have found a truly wonderful proof for this, but the margin is too small to hold it."

Assuming that Fermat actually had a proof, and his mathematical talents were of such a high order that it was certainly possible, he would have saved the succeeding generations of mathematicians unending hours of labour if he had found room for it in the margin. Almost every great mathematician since Fermat has sought for that proof but none has ever succeeded. Many pairs of integers are known the sum of whose squares is also a square, e.g., $3^2+4^2=5^2$, $6^2+8^2=10^2$, but no three integers have been found where the sum of the cubes of any two of them is equal to the cube of the third. It was Fermat's contention that this would be true for *every* integer when $n>2$. By extended calculation it has been shown that Fermat's theorem is true for n upto 617. But Fermat meant it for every $n>2$.

In 1816 the Paris Academy proposed a prize for the solution of Fermat's theorem. A friend of Gauss, by name Olbers, wrote to him, "It seems right to me, dear Gauss, that you should get busy about this." Gauss replied, "I am very much obliged for your news about the Paris prize but I confess that Fermat's theorem as an isolated proposition has very little interest for me because I could very easily lay down a multitude of such propositions which one could neither prove nor dispose of."

Writing in *Mathematics—Queen and Servant of Science*, E.T. Bell observes,"In passing, may I request any reader of this section who imagines he has a proof, not to send it to me! I have examined well over a hundred fallacious attempts and I feel that I have done my share. One such many years ago stuck me for three weeks. I felt there was a mistake but could not find it. In desperation, I turned the author's manuscript to a bright girl in my class who detected the blunder in half an hour. This was not as humiliating as it might have been."

Lindermann (1852-1939) who in 1882 immortalized himself by proving transcendence of π (pi), published towards the end of his life, at his own expense, a long alleged proof. The fatal mistake was almost at the beginning of the argument.

Kummer went more deeply than any one else into Fermat's last theorem. About 1845, he thought he had succeeded in solving the theorem but Dirichlet pointed out the mistake. In doing this Kummer created a totally new species of numbers which he called 'Ideals'.

Anyone contemplating a proof of Fermat's theorem may be interested in what Hilbert said in 1920 when asked why he did not try. He said, "Before beginning, I should put in three years of intensive study and I haven't that much time to squander on a probable failure."

Euler (1770) gave an incomplete proof for $n=3$, subsequently completed by others. Now since $x^{mn}=(x^m)^n$ and so on, for y^{mn} and z^{mn} it was found sufficient to prove the theorem for odd prime exponent of $n>3$. Two cases arise. Case I: n does not divide any of the numbers x, y and z; case II: n does divide one of them. (This case is more difficult to prove.)

For case I, Rosser in 1940 proved that the theorem is true for all odd primes not exceeding 41,000,000. Lehmer in 1941 bettered the result to 25,37,47,889. For case II, upto 1950, the limit was 607 as proved by Vandiver.

Wieferich in 1909 proved that if in the first case there are solutions x, y, z, the prime n must be such that $(2^{n-1}-1)$ is divisible by n^2. The only n less than 2,000 which fits in is 1093. From this Gottschalk in 1938 deduced that there are no solutions in the first case if n is a Fermat's prime $(2^{2^n}+1)$ or a Mersenne prime 2^p-1, where p is a prime. (It is still a source of wonder—though Fermat had an uncanny way of determining the values of p for which (2^p-1) is a prime—that he, in response to a letter which asked whether 100895598169 was a prime, straightway replied that it was the product of 898423 and 112303 and that each of these numbers was a prime. Without a general formula, mathematicians, even today, might spend years hunting for the correct answer.) Mersenne prime is defined as $M_p=2^p-1$. If p is prime >2 then M_p is a prime if and only if M_p divides the term $(p-1)$ in the sequence. Is this historically suggestive or not?

The greatest service that Fermat's last theorem has rendered so far to mathematics is its instigation of the theory of algebraic numbers. This theory was responsible for some of the guiding concepts, for instance, 'ideals' in modern algebra (mentioned earlier) which in turn have reacted on modern mathematical physics.

Of all his great contributions to mathematics, Fermat's most celebrated legacy is this puzzle which three centuries of mathematical investigations have not solved and which sceptics believe Fermat himself never solved.

C.B.L. VERMA

Coloured clouds of Jupiter

WHEN viewed through a telescope the outer planets of the solar system and their satellites show multi-coloured cloud schemes in their atmospheres. The best known of such coloured clouds is the Great Red Spot of Jupiter with its array of colours in which red and yellow are the most common. Early astronomers had speculated these colours to be the result of chemicals in the outer atmosphere of the planets. In the case of Jupiter, for example, it was believed that the Red Spot was due to the presence of sulphur and complex ammonium polysulphides in the planet's atmosphere. The results of recent experiments conducted by Thomas Scattergood and his coworkers at the State University of New York prove that it is indeed so. Starting with the hypothesis that the complex colour-causing molecules must have formed from simple molecules in the planetary atmospheres, the scientists have successfully synthesised such molecules in the laboratory.

The idea of complex molecules forming out of simple molecules in the atmosphere is not new. This idea has been accepted as the beginning of origin of life on earth, millions of years ago. In the past scientists have tested the hypothesis by synthesising a variety of organic molecules from simple molecules, using a variety of energy sources that might have existed millions of years ago on earth. The present effort differs from the earlier attempts in that the scientists have used for the first time high energy protons as the energy source. High energy protons in the cosmic rays are trapped in the radiation belts of planets like Jupiter with high magnetic fields.

In their experiments, reported in a recent issue of *Nature*, the scientists used four different gas mixtures and high energy protons from a particle accelerator. They found that when an equal mixture of methane and ammonia in an aluminium container was bombarded with protons, an orange brown liquid resulted. This mixture on analysis showed to contain a mixture of complex organic molecules, including cyclic alkyl amide and hexamethylene tetramine. In another experiment a mixture of methane, ammonia, and hydrogen sulphide gave elemental sulphur as a polymer and a complex mixture of organic compounds. This liquid mixture was yellow in colour. In the third experiment an equal mixture of methane and nitrogen gave a coloured liquid of unknown composition, while the fourth experiment with methane alone gave a colourless liquid.

P.K. TATINENI

Keeping deserts under control

THE north-western part of our country is faced with a very challenging problem of the desert areas. The hard core desert extends over an area of about 2 lakh square kilometres, most of which lies in the western parts of Rajasthan. The population in this area is sparse. The soils of the desert area are in general sandy, reddish brown to yellowish brown and grey in colour and are calcareous with concretionary lime accumulations at varying depths. The soil fertility in this region is generally poor. In addition to this, there are several other limiting factors such as low and erratic precipitation, non-availability of surface water and limited availability at great depths of groundwater. On account of this the productivity of the region is very low. Due to the low productivity of the region and the difficulties of development the desert has been a cause of regional disparities. This area has not been able to participate in the benefits of the break-through in agriculture—the green revolution. Added to these problems is the problem of extension of the desert towards east. This is due to the fact that the area is subject to heavy land erosion due to high wind velocity, and more than 50% of this area is covered by sand dunes which are constantly shifting. The problem of controlling the extension of the desert is therefore of utmost importance, in addition to the other equally important problems of these areas, viz., economic and social.

Factors causing the extension of deserts

The soil of the desert areas is easily eroded being devoid of any vegetal cover. As such, the extension of the desert mainly results from the erosion and transportation of the loose dry sand from the desert area to the eastern part of the country. The quantity of dry, fine sand (100-150μ) transported by the direct action of the wind is found to be an exponential function of the velocity of the wind.

It has also been found that for wind velocities less than 5 metres per second the movement of sand becomes ineffective.

Preventive measures

The erosion of the soil can be checked by providing a vegetal covering. This would however need huge quantities of good quality water to facilitate the growth of different varieties of plants. But the average annual rainfall of the region is quite low and uncertain. Moreover, the surveys conducted have indicated that in the arid region the surface water is extremely limited and most of the well waters of this region are saline and can be used only for irrigation of salt-tolerating varieties of crop. However, recent groundwater surveys have indicated a potential for installing about 900 tube-wells in the arid regions with an average discharge ranging between 40,000 to 70,000 litres per hour. With such a limited water potential the provision of a vegetal cover for the entire land of the arid region may not be possible. But certain measures as indicated below, which may be quite effective for soil-stabilisation in the arid regions, may still be undertaken.

Intermittent vegetal shelter belts. Surface soil erosion and sand storms leading to sand casting of the cultivable fields and homesteads can be controlled by creating shelter belts of suitable tree growth. The growth of the trees and shrubs in these belts may be supported by introducing canal water or tube-well water. Such shelter belts tend to break the wind and form barriers for sand movement. In order to assess the effectiveness of artificial barriers against wind erosion, studies have been made of the velocity distribution downstream of a single and a series of three successive snow fences in the field. A comparison of the same with the velocities measured downstream of models of the fences placed in a wind tunnel leads to the following conclusions:

(i) The wind tunnel approach gives a reasonable estimate of the effectiveness of full-scale surface barriers under atmospheric conditions.

(ii) The velocity distributions taken downstream of the barriers indicate considerable difference in the flow pattern and pressure distribution between the flow over a single barrier and a series of them.

(iii) A series of three successive barriers is not enough to obtain a beneficial ground effect. A general lessening of velocity with distance travelled over the successive barriers indicates, however, that an accumulative effect might be obtained in a system containing a larger number of successive barriers extending over a great length.

On the basis of the above-cited study it may be stated that in order to enforce effective soil-stabilisation a large number of vegetal shelter belts should be developed in the arid region. These belts should be so oriented that they are normal to the general direction of the blowing wind. As regards the spacing of these belts no specific distance can be mentioned. However, in this context the wind tunnel studies conducted to study the characteristics of flow past two dimensional normal plates set in contact with the boundary may be mentioned. They have indicated that the length of the standing eddy behind a sharp-edged flat plate kept on a plane boundary is about 12 times the height of the plate. Although the vegetal shelter belt may have different behaviour as compared with that of a solid barrier, yet some guidance may be obtained from the results of these studies in deciding the spacing of the shelter belts. Accordingly, it may be stated that in order to achieve an accumulative effect of these belts the spacing should be less than about 12 times the average height of the trees grown in the belt.

Stabilisation of sand dunes. The provision of vegetal shelter belts to stabilise the soil in the arid regions may be adopted only if the land is fairly levelled and there are no high sand dunes in the area.

In areas where land levels are not too high the sand dunes may be levelled and ploughed and shelter belts may be provided. Furthermore, if possible, the land between the adjacent shelter belts may be brought into cultivation with irrigation water. However, where the sand dunes are of great height, the stabilisation can be made effective by growing suitable grasses and trees starting from the periphery and going up. This will be possible only with the introduction of canal water or tubewell water. After a few years of continuous vegetation growth the productivity of the land would increase. Even brakish water or water of low salt content can also support various types of good foodder grass which can stabilize sand dunes.

Dry land farming. Dry land farming is a system of producing crops under conditions of low rainfall through efficient management and utilisation of rain water. The technique of dry land farming is being successfully adopted in several arid regions of the world and it has been considerably developed during the last 30 years. The main basis of dry land farming is the conservation of all the moisture that falls on the land in the form of rainfall. Thus, even if the total rainfall in the region is too small to be effective, by collecting all of it on a large area as run-off and allowing it to soak into a limited area the most efficient use of the available moisture is made. Moreover, new methods of harnessing rain water that goes as run-off on the land are now available at low cost with locally available materials. Similarly, losses by infiltration or evaporation from storage surface tanks can be stopped by sealing the bottoms of the tanks with a suitable mixture of bentonic clay with sodium fluoride and sodium carbonate.

Evaporation losses from surface areas can also be reduced to a great extent by digging small tanks to store run-off water, the surface of which is covered entirely with cheap floating frames made of polythene sheets or palm leaf mats.

Thus with proper dry land farming techniques in arid and semi-arid regions even in drought years it is possible to cultivate the land. The yields would be high enough to cover the cost of production and make the area self sufficient.

Some of the techniques which may be adopted to control the extension of the desert have been briefly reviewed. These techniques if adopted will lead to increased productivity and overall economic growth of the arid regions.

P. N. Modi

What does urinalysis tell ?

URINE is an extremely complex aqueous solution of various organic and inorganic substances. Most of the substances are either waste products from the body metabolism or products derived directly from the food eaten. The most important organic constituents are urea, uric acid and creatinine. The chief inorganic constituents are the chlorides, phosphates, sulphates and ammonia.

Certain substances appear in the urine only when pathologic conditions are present. The most important of these are proteins, carbohydrates,acetone, bile salts and haemoglobin. Hormones appear in the urine in varying concentrations and their detection and estimation are of a very practical clinical significance. For example, the common pregnancy tests depend upon the excretion of hormones. Besides these substances in solution, urine contains various microscopic structures which are of great diagonistic importance.

Normal constituents

The chlorides which are derived from food are excreted mainly as sodium chloride. Excretion of chloride is decreased in cases of burns, diarrhoea and pneumonia. Phosphates present in the urine are derived mainly from food. From clinical point of view, variation in the amount of phosphates in the urine is of little significance. Urea, one of the end products of protein metabolism, is the most important constituent of urine. About 20 to 35 gm of urea is excreted in 24 hours in the urine of a normal individual on an average mixed diet. Under abnormal conditions the amount changes. It is increased in fevers and in many other conditions accompanied by increased metabolism. A decrease in the amount is due either to decreased formation in the body, such as may occur in severe liver disease, or to retention of urea, as in cases of kidney failure.

Uric acid is present in urine in the form of urates chiefly of sodium and potassium. The daily output of uric acid in the urine is about 0.4 to 1 gm. The greatest increase of uric acid in urine occurs in leukaemia in which there is extensive damage of leucocytes, and in diseases associated with active destruction of the liver. An increase is also noted in cases of acute fever.

A small amount of ammonia in the form of ammonium salts of hydrochloric, phosphoric and sulphuric acids is always present in urine. Estimated as NH_3, its normal average production is about 0.7 gm in 24 hours. Under normal conditions most of the ammonia that is produced from metabolic processes is transformed into urea. When, however, acids are present in excess, either from ingestion of mineral acids or from abnormal production of acid within the body, ammonia combines with them and is so excreted. There is a corresponding decrease in the amount of urea in the urine. The excretion of ammonia is also increased in cirrhosis and other destructive diseases of the liver.

Abnormal constituents

Substances that appear in the urine only under abnormal conditions include proteins, sugar, acetone bodies, bile, haemoglobin, etc. They are very important from the clinical point of view.

Serum albumin and serum globulin are the most important proteins that may be present in the urine. Their presence in the urine is known as 'albuminuria".

Excessive muscular exertion by persons unaccustomed to it, excessive ingestion of proteins, prolonged cold baths, the latter stages of pregnancy and child-birth may produce albuminuria.

The presence of glucose in urine in diabetes mellitus is well known. This is due to disturbed glucose metabolism in the body as a result of insufficient insulin.

Acetone bodies are closely related substances—acetone, diacetic acid and beta-oxybutyric acid. Excessive production of diacetic acid and beta-oxybutyric acid causes acid intoxication. Traces of acetone which cannot be detected by ordinary tests are present in the urine under normal conditions. Large amounts may be present when the intake of carbohydrates is limited in diabetes mellitus and in fever or gastrointestinal disturbances. Tests for acetone are as important as for glucose in diabetics. The urine in case of jaundice contains bile pigments also which impart a yellow to brown colour to the urine.

Microscopic examination

A careful microscopic study of the sediment obtained after centrifugation of urine often reveals structures of diagnostic importance. The crystalline sediments of acidic urine may contain uric acid, urates and calcium oxalate, whereas phosphates, calcium carbonate, and ammonium biurate may be found in alkaline urine. The main organised structures in urinary sediments are tube casts, epithelial cells, leucocytes, erythrocytes, spermatozoa, bacteria and animal parasites.

The presence of tube casts indicates some pathologic change in the kidney like irritation and congestion of the kidney. Few leucocytes are present in normal urine. Under abnromal conditions, however, their number increases. This indicates suppuration in some part of the urinary tract such as the bladder, urethra, or renal pelvis. Under normal conditions the urine is free from bacteria in the bladder but becomes contaminated in passing through the urethra. In many infectious diseases like typhoid fever and tuberculosis the specific bacteria may be eliminated in the urine.

Thus, as the end product of a complicated and delicately balanced physiological system, urine is a valuable index to many normal and pathologic mechanisms.

S.C. Hari

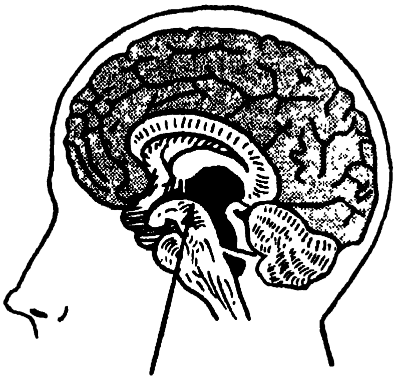
Hypothalamus and aging

SITUATED somewhat centrally in the brain the hypothalamus forms the floor of the diencephalon which connects the cerebral hemispheres with the rest of the brain. Further, this hypothalamic floor is pushed out into a stalk, the infundibulum, which is continuous with the pituitary. Such an important location is perhaps necessary for a structure which controls a variety of complicated functions involving muscles and glands dispersed throughout the body.

The hypothalamus is well developed in all vertebrates including mammals but it is only in the latter that its capacity to perform a variety of functions becomes evident. In fact, it may not be easy to describe adequately what the hypothalamus may mean for the life of a mammal, but the fact that centres for so many vital functions lie close together should be sufficient to reflect on the importance of this region. Also, the hypothalamic region is more richly supplied with blood vessels and is more sensitive to changes in the composition of the blood than any other region in the brain.

The cells of the hypothalamus are grouped into nuclei that influence a wide range of visceral and motor functions from temperature regulation, sugar metabolism, heart rate, blood pressure, movement of the gut, salt balance, and water regulation to sleep and sexual functions. In many of these activities the hypothalamus acts in association with the pituitary whose secretions are also controlled by it. A group of centres, higher up in hierarchy, controls many lower groups each of which, in turn, is responsible for the control of many other functions.

In view of the important role which the hypothalamus plays in the life of an animal, it is quite natural to assume that it also plays an important role in the aging of an



HYPOTHALAMUS

individual. Unfortunately our knowledge in this regard is so inadequate that it may only be possible just to advance some generalisations on its role in aging. It is known however that with aging there is a gradual impairment of the hypothalamic regulatory mechanisms which may account for many of the age-associated decrements in animals.

The relation of food habits to aging is well known. Overeating leads to obesity and it accelerates the diseases of old age, while fasting prolongs life. In rats, overfeeding has been shown to reduce the life-span by half. Since the intake of food is regulated by the feeding centres in the ventromedial nucleus of the hypothalamus, the aging changes characteristic of overeating may also be regulated by the above centres. Further, destruction of the ventromedial nucleus of the hypothalamus in the rat has been shown to result in overeating and concomitant obesity.

Temperature, whether environmental or internal, is known to affect aging and hence the longevity of a species greatly. In lower animals and poikilothermic vertebrates a lowered body or environmental temperature has been shown to increase the life span. In mammals, the homeotherms, who maintain a constant body temperature, although such a result has not been obtained so far, one cannot rule out the possibility altogether. In fact, gerontologists have already put forward an optimistic proposition that in man if the body temperature of 98.6° F could be lowered by just one degree the average longevity could be increased by thirty years. Since the centres for the control of body temperature lie in the hypothalamus, a greater understanding of its mechanisms may in the long run pave the way for the realisation of the above end.

S. C. PADHI

Microorganisms in milk

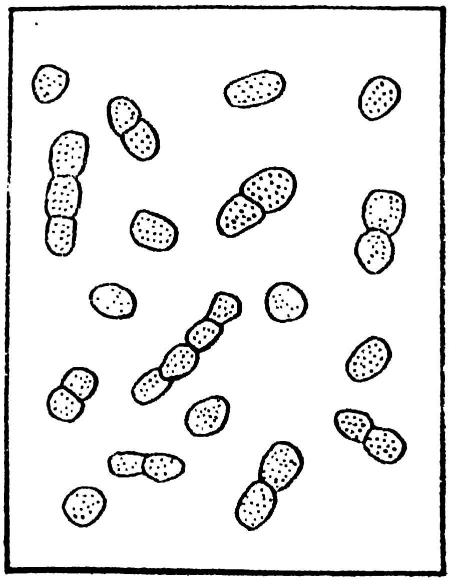
MILK, which is considered to be the most satisfactory single food substance elaborated by Nature, is an excellent culture medium for many species of bacteria. It has the necessary moisture, proteins and mineral salts. Some organisms can break down protein and a few can utilize fats. The lactose can be used as a nutrient by several species. In fact, milk has been found to be a suitable medium for the development of hundreds of bacterial species, both saprophytic and pathogenic (i.e., disease-producing).

A number of pathogenic, non-pathogenic and saprophytic bacteria are found in milk. Among them the lactic acid bacteria are concerned in the production of lactic acid from the lactose sugar in milk. Some produce relatively large amounts of lactic acid; others form smaller amounts together with other products. These represent several different families, but the more important ones belong to the family Lactobacillaceae.

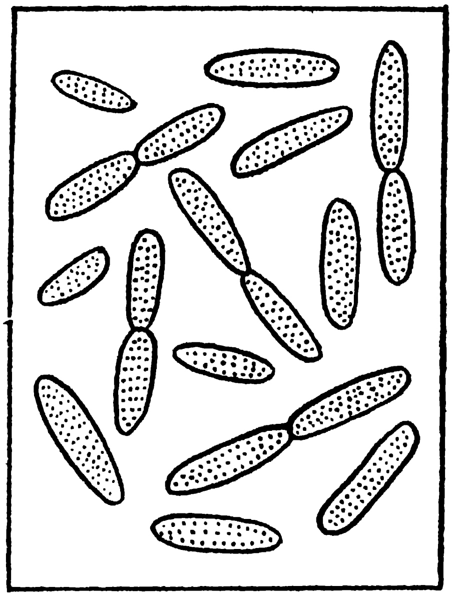
The principal lactic acid-producing bacteria include: (1) *Streptococcus lactis* and related species, and (2) *Lactobacillus* species.

Streptococus lactis plays a greater role in the normal souring of milk, for it is more extensively introduced into milk from plant materials and dust and from improperly sanitized utensils. *S. lactis* is a common contaminant of milk and milk products. However, it seldom occurs in the udders of cows. Hay and grains are believed to be the natural habitat of the organism. Since these are consumed by the cattle, the organisms are found in manure. It is generally believed that the organism finds its way into milk from manurial contamination. It multiplies there very rapidly and ferments the lactose.

Cells of *S. lactis* are ovoid in shape and elongated in the direction of the chain, measuring 0.5 to 1μ in diameter. They occur mostly in pairs or short chains, sometimes in long chains, and are gram-positive.



Streptococcus lactis (diagrammatic)



Lactobacillus species

S. cremoris is commonly found in raw milk and milk products, and commercial starters for butter and cheese manufacture. Probably of plant origin, the characteristics of this organism are similar to *S. lactis.*

The *Lactobacillus* species are found widely distributed in milk, butter, cheese, sour and aromatic foods, cattle feed, normal saliva, gastric juice, fermented milk, soil, faeces, etc. These are rod-shaped organisms, often long and slender. They are non-motile and gram-positive. Several species grow at relatively high (50° to 65°C). temperatures. The important species are homeofermentative and are found in dairy products. They include *L. casei*, *L. acidopholus*, *L. bulgaricus*, *L. helveticus* and *L. plantarum*.

In addition to acid production, other undesirable changes are brought about by bacteria in milk. The proteins may get putrefied with the formation of disagreeable flavours. This is done by many species of genera Bacillus, Clostridium, Proteus and numerous other forms. Species of *Sarcina* are very common in milk. Early production of lactic acid generally inhibits all these forms.

Blue milk has occasionally been reported. This is generally due to *Pseudomonas syncyanea* growing in an acid medium. A red color sometimes occurs in milk due to the growth of *Serratia marcescens* or related species.

Undoubtedly some of the most objectionable bacteria encountered in milk are the psychrophiles. These organisms grow well at refrigerator temperatures. They produce little acid but breakdown proteins and sometimes fats. The degradation products cause bitter flavours and off odours in milk, cream and cottage cheese. As a rule members of the genera Pseudomonas, Alcaligenes, Flavobacterium and Achromobacter and some of the Coliforms are the most common cause of this type of spoilage.

Occassionally milk becomes infected with pathogenic bacteria. However this has become less common with improved milk sanitation and the increasing practice of pasteurisation.

The health of the cow is an important factor because a number of diseases of cattle, including tubeculosis, brucellosis, Q fever, Salmonelloses or Staphylococcic infection may be transmitted to man through the medium of milk. The organisms of most of these diseases may get into the milk either directly from the udder or indirectly through infected body discharges from the animal.

The following pathogenic bacteria produce various diseases of cattle which are transmitted to man.

1. *Mycobacterium bovis* is the causative agent of tuberculosis in cattle. The organism is very similar in appearance to the human type. Children, especially those under five years of age may become infected by drinking milk from tuberculous cows. It is doubtful that the organism multiplies in milk. but it can live and may retain its virulence for a considerable time.

2. *Brucella abortus* is frequently found in cow milk. It produces contagious abortion in cows. *B. melitensis* causes a similar disease in goats and Malta fever in humans. However, human brucellosis may be caused by drinking raw milk containing any one of these species.

3. *Coxiella burnetii* is a causative agent of a relatively newly recognised disease of cattle known as Q fever. This organism may be transmitted to man through milk.

4. Some strains of *Staphylococcus* are capable of elaborating a potent exotoxin. The consumption of milk containing such toxin-producing strain may result in severe gastroenteritis.

INDRESH P. SAXENA

Soybean—an ideal food

SOYBEAN is one of the oldest crops grown by man. The assumed central area of distribution of soybean is tropical South Asia from where it has migrated to Central Africa and the Oceania. Manchuria was once leading in commercial production of soybean, but in the last 20 years soybean cultivation has assumed much importance in the United States. It is a food crop in Indonesia, Japan, Korea, U.S.S.R, Brazil and Canada. Approximately 3 crore hectares are now under soy cultivation in the world.

Although India started soy cultivation earlier than 1930s, its contribution to the world's total production to-day is negligible. In India, it has been estimated, soybean occupies an area of 17,200 hectares with a production of 6,000 tons per year.

Miracle crop

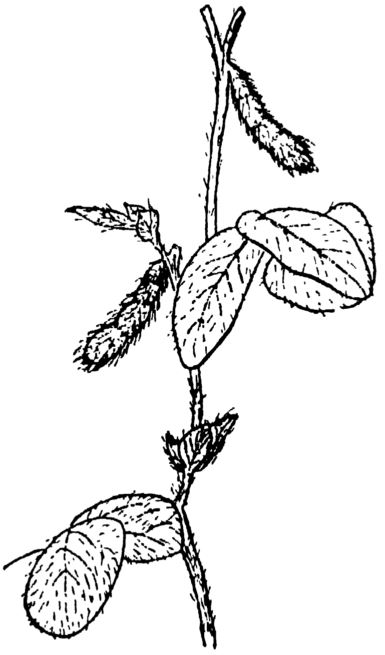
Soybean plant is a small, bushy, erect or prostrate annual. It has been aptly called the 'miracle crop' since it matures early, gives a larger yield, and produces a better seed in all climates and in all soils. It is similar to maize in climatic requirements. The seed is usually sown in fertile loamy and sandy loamy soils during June or July, in rows of 45-60 cm apart, at the rate of 10-15 kg per hectare. It is useful to grow soy mixed with maize and jowar. Soybean, being a legume, fixes nitrogen which, in turn, is made available to the maize crop.

At present, the two recommended varieties of soybean are 'Hill' and 'Davis'. They mature in about 90-95 days in the main season and in about 105 days in summer. Under rain-fed conditions the average yield is 10-17.5 quintals per hectare.

The soybean has been relatively free from serious epidemic diseases, except for the wide-spread attack by sclerotial or blight (*Scleortium rolfsii*) and the root-knot or nematode disease (*Heterodora marioni*).

It is cultivated primarily for oil and protein with uses more diverse than most other legumes. Seeds contain about 23% of oil and nearly 48% of protein. This is the richest source of vegetable protein and oil among the pulses.

As an additive or supplement to other foods, soybean is an excellent protein source, as well as a source for several important vitamins and minerals like phosphorous, calcium and iron. The carbohydrates of soybean contain comparatively low starch and sugar. The section of people who have to restrict their intake of starch and sugar may take this as supplement food. It is essential that the beans be scientifically processed before making into flour. The toxic material found in the husk and the trypsin inhibitor in the beans must be first removed to make the high protein content easily digestible. Among several varieties, K-16, an Indian variety, contains the highest percentage of protein (38.5%). The other varieties contain only 35.6% of crude protein, but they are richer in fat content (23%). Soybean, being low in carbohydrates and rich in non-acid proteins, is highly recommended as a safe food for diabetics, heart patients and those suffering from liver trouble and kidney disorders. It is an ideal protein food for vegetarians and non-fattening food for obese.



Soy plant

Vegetable meat versatility of soybean is so good that almost any flavour of flesh—fish or fowl—may be incorporated in soybean products. A Japanese food manufacturer has prepared a meat substitute from soybean after extracting the oil from the seeds. It is claimed that artificial soy-meat is more nutritive and healthier than animal meat because of its non-fattening property and is easily digestible. The vegetable meat is 95% protein and has no smell, taste or colour. A nutritive infant food is also prepared from soybean with barley malt and skimmed milk powder. Besides, attempts have been made to introduce soybean as the raw material for protein-rich artificial milk. It is also said to be a safe liquid food for persons having high blood pressure, diabetes, tuberculosis, asthma, bronchitis, etc. A cup of soy-milk with a teaspoon of honey taken every night is said to be a wonderful nerve and protein tonic to improve brain fag, mental disorders, hysteria, etc. It tones up the nervous system due to its rich concentration of lecithin, vitamin B and glutamic acid. Soybean curds are also prepared from this milk which can be used as a substitute for cow's milk curds.

Oil

Soybean is a source of an exceedingly valuable oil. The oil is in good demand by the vanaspati industry and is extracted from the seeds by hydraulic or expellar processes. The oil may be used in the manufacture of candles, soaps, varnishes, lac substitutes, paints, linoleum, rubber substances, cleaning agents, insecticides and disinfectants. Chemically, the soy oil (vegetable oil) is close to animal fats. It is solid at ordinary temperature.

Considerable interest has been shown in recent years in lowering the linolenic acid content of the soybean oil because linolenic acid is partly responsible for the undesirable flavour reversion in refined soy-oil. But since this acid is a valuable component of soybean oil, its reduction is not desirable. The soy-oil contains about 60% of polyunsaturated fatty acids and is therefore highly digestible. Due to its low cholesterol content soybean oil is preferred as edible oil.

The oil content in the plant is known to increase very rapidly from the time of fruiting. However, percentage of oil stored in the seeds is greatly affected by temperature. It is observed that higher the temperature, more will be the stored oil in the seeds.

Soybean is today a major crop in the world. Its protein is the best and cheapest source available of vegetable protein. Adoption of new methods and new crop patterns by changing our food habits in favour of high nutritive foods will lessen our dependence on cereals and help cut down food imports. Soybean has changed the economy of the United States and several other countries. It is high time that we in India take up this crop seriously.

V. Bhaskar

The magnetic earth

IT is a common knowledge that the earth has a magnetic field. When a small magnetic needle is freely suspended on the surface of the earth, it approximately points north-south direction. This led early theorists to believe that our earth behaves as a magnet with its north pole somewhere near geographical south pole and south pole near geographical north pole. The British physician William Gilbert in his book *De Magnete* in the year 1600 was the first person to show that magnetic effect of earth was not due to isolated regions of land but due to the entire planet. It is now also known that earth's magnetic field is not constant over the entire globe but varies from place to place.

Magnetic field reversals

The intensity of magnetic field is not constant over any particular point of the earth. It changes with time also. During 1830-1940 the average intensity of earth's magnetic field decreased by 3-5 per cent but the mean magnetic intensity has remained constant since 1940. Moreover, if we analyse the rocks on the surface of the earth and underground, we will find that earth's magnetic field has reversed many times during the past. During the process of formation, rocks get magnetised in the direction of earth's magnetic field. Some of these rocks have been found to show magnetism in the direction of earth's present field and others just in the opposite direction. Sudden field reversals are supposed to occur over a period of million years.

Secular changes

Apart from field reversals there are other changes also. They are called "Secular changes". They are gradual changes extending over a long period. Declinaion, which is defined as an angle between geographical and magnetic meridian at a place, changes over a period of 960 years approximately. Other elements, e.g., dip and horizontal intensity also vary but their rate of variation is much slower. These secular changes are regarded as results of slow movement of earth's magnetic poles around geographical poles in a circle of 17°. There are places on the earth where variation is even larger. Such places are known as magnetic focii. There is yet another type of variation known as Lunar variation. This is due to the moon. This occurs two times a day and fifty-six times in twenty-eight days. The lunar variation coincides with the time of formation of tides in the seas. When tides occur in the sea, the barometric pressure falls and creates atmospheric disturbances. The movement of electrically charged particles in the atmosphere constitutes a current which probably affects earth's magnetic field.

Routine changes

There are daily geomagnetic changes which are exremely small to be detected by ordinary instruments. There are however a special type of instruments known as magnetographs for recording them. The variations are very small but follow the same course everyday. Moreover, a record of mean value of maximum daily variation of an element during any year shows that it fluctuates every eleven years and generally coincides with the maximum number of sunspots. Magnetic storms also influence magnetic elements. They usually coincide with the display of Aurora Borealis and Aurora Australis in northern and southern sky respectively in polar regions. Magnetic storms are produced at the time of large number of sunspots in the sun.

Theories of geomagnetism

To account for earth's magnetism various theories have been proposed from time to time. Once it was believed that the earth was a uniformly magnetised sphere as it displayed symmetrical lines of force. A huge bar magnet was also supposed to be located at the centre of earth. Gilbert proposed that the earth is composed of magnetite rocks and they are responsible for earth's magnetism. None of these theories was, however, tenable. For example, very small amount of magnetite rocks are found in the earth's crust and so cannot account for its magnetic properties. Ferromagnetic material, which is abundantly present in the earth's crust was also thought to be responsible for earth's magnetism. But as we go deeper inside earth's crust the temperature rises and the ferromagnetic material loses magnetic properties beyond Curie point. The field strength also decreases with depth. Successive theories predicted that earth's magnetism may be due to ionised gases in the ionosphere which extends from a height of 50 km to a few thousand km including Van Allen radiation belts.

At this height of atmosphere density is low and there is free mobility of charged ions in groups which constitute a current. This current may account for earth's magnetic field. But calculations show that the current contributes only a small fraction of it. At best, this atmospheric current can explain the lunar or solar variations in magnetic elements of earth at a particular place.

As early as 1830, the German mathematician Karl Friedrich Gauss (1777-1855) showed that most of the magnetic field originates inside the earth. Present studies of primary (*P*-wave) and secondary (*S*-wave) earthquake waves have shown that the interior of the earth consists of two parts: the mantle and the core. *P*-wave is a longitudinal wave in which the particles of the medium vibrate in a direction parallel to the direction of propagation whereas *S*-wave is a transverse wave in which particles of the medium vibrate in a direction perpendicular to the direction of propagation. Moreover, *P*-wave is propagated with higher speed than *S*-wave. Mantle is the outer part of earth's crust made up of rocks, more or less similar to those on earth's surface made of silicates and oxides. The two are insulators by nature. Hence the mantle must be a poor conductor and the current extremely small. We can thus disregard mantle as the source of earth's magnetism.

The central part of the earth is called the core and is set off from the mantle by a sharp boundary. The core has a diameter of 7,000 km. From seismological and geological evidence in the form of volcanic eruption it is definitely known to be liquid and not a solid. Chemically it is molten iron. The temperature of the core is in the neighbourhood of 4000 K. The main part of the earth's magnetism owes its origin to electric current flowing in the metallic core. The magnetic field originates due to mechanical motion of the conducting fluid. The fluid as it moves is capable of amplifying electric currents and hence the magnetic field. This is analogous to the principle of a dynamo. The magnetic field is nearly 50 times stronger inside the core than near the surface. What we see outside is a sort of leakage of internal and heavily twisted field which the complicated fluid motion generates and sustains by amplification.

The rotation of the earth generates mechanical influence upon the motion of the core which results in the creation of vortices of certain preferred types. This explains the presence of symmetry in magnetic field about earth's axis.

What is the source of energy responsible for the motion of the core? Some scientists are of the opinion that motion of the core is due to thermal convection. As the earth slowly cools, obeying the laws of thermodynamics, the heat is delivered from the core to the mantle. Since actual motion of the particles of the medium is the most efficient form of heat transport in a fluid, motion does take place in the core atleast from the interior to the outside and *vice versa*. This is then supplemented by the rotation of the earth about its axis.

J. MOHANTY

Weather modification by high energy electrons

DR. F. WINTERBURG of the University of Nevada (U.S.A.) in a recent issue of *Nature* has put forward an interesting idea of shooting high energy electrons into clouds to bring out some modifications in the weather of a region. In the past a variety of solid particles—ranging from ice droplets to sodium chloride crystals—have been used fairly successfully to seed clouds and bring out changes in the weather. Such cloud seeding has been used to cause rains or to prevent hailstorms, etc. However such weather modification procedures had always sufferred from the practical difficulties of dropping the seed material at the right place at the right time. Though aircraft have been used to a great extent in such experiments, flying into storm clouds means an inherent danger to the aircraft as well as to the crew. Recently the Russians have reported successful prevention of hailstorm by shooting anti-aircraft guns into the storm clouds.

Dr. Winterburg suggests that his method of shooting beams of high-energy electrons into clouds will produce three beneficial effects: The charged electrons would increase the charge of the cloud region and this may mean enhancement in the formation of water droplets; it will reduce the chances of lightening by increasing the conductivity of air; and finally it can also create electric channels to the ground to trigger discharge of the cloud's electric energy.

The one disadvantage of the method is that the maximum range of an electronic beam is only 280 metres. This is the range for electrons with an energy of 50 million electron volts (Mev); at this energy the electrons will have a velocity approaching that of light. However, Dr. Winterburg feels, the effective range can be increased by firing the electrons with a rapid-fire mechanism. Once the first burst of electrons is 'fired', this will heat up the air and cause it to expand. A second burst when fired into this rarefied air will penetrate futher. The successive bursts will go still further and so on. According to Dr. Winterburg a sequence of ten bursts can go up to 2400 metres.

He estimates that the electrons can be given the energy and range by a block of capacitors, which can be mounted on a heavy truck or an aircraft. Between each burst of electron fire, the capacitors can be recharged.

P.K. TATINENI

Lungfish that made history

ALL living creatures have an ancestral history, dating back to a million to several millions of years. Till recently, it was believed that these ancestors became extinct long ago and none of them lives on this planet now.

The ancestors of a vast majority of the present-day fishes appeared in the Devonian period, over 300 million years ago. They included the lungfishes also, from which the land animals appear to have evolved later. The surviving lungfishes which evolved from the ancestral stock live in rivers or marshy areas and are confined in distribution to the continents of Australia, Africa and South America. The Australian lungfish is found in two rivers of Queensland. The African lungfish inhabits the river basins of tropical Africa over a wide area. The South American lungfish is confined to the area of the Amazon basin.

The distribution of the ancestors of lungfishes, called Coelacanths, was extensive when the continents were closer. Their remains are prominent in the rocks of Devonian period. However, till 1938 they were considered as an extinct group, having perished in the Upper Cretaceous, about 70 million years ago.

On the Christmas Eve in 1939, a strange fish was caught in a trawl net off the mouth of the Chalumna River in South Africa. This was found to be a surviving Coelacanth (Fig. 1). Professor J.L.B. Smith, a noted ichthyologist of South Africa, examined the fish and named it *Latimeria.* At about the same time of the year, in 1952, he obtained a second fish off the Comoro Islands, near Madagascar, and named it *Malania.* A third specimen was caught from the location of the second fish, but resembled in features the first fish. The living Coelacanths measure five feet while the ancestors measured from a few inches to five feet. They also show the essential features of the extinct Coelacenths. Obviously, there has been very little change throughout the 300 million years of their history which is an unique feature. Although they are believed to have become extinct 70 million years ago, it does not mean that the living Coelacanths are as old as 70 million years. In all probability, the present day Coelacanths are only a few years old, and they live as long as any other fish of the present time.

The Coelacanths of the Devonian period were marine, but in the Carboniferous, about 240 million years ago, they were largely confined to freshwater. In the Triassic, about 150 million years ago, they had returned to the sea again and were living in shallow seas. Subsequently, they moved to deeper

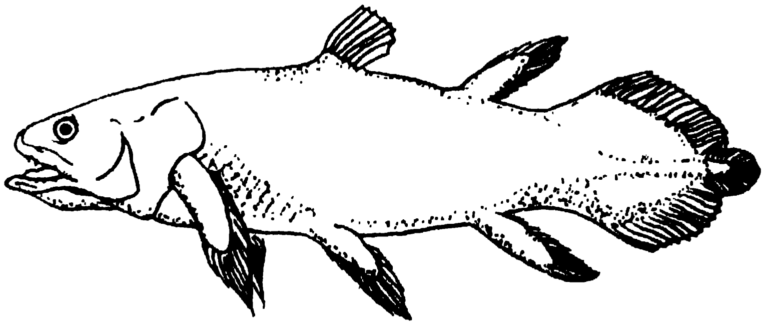


Fig. 1. A Coelacanth

waters of the sea. Despite these environmental changes, there was little change in the structure of the Coelacanths, possibly due to the adaptability of the fish without structural changes. This is what we find now in the living Coelacanth, *Latimeria*.

Fossil remains of the Coelacanths are rare in most of the rocks, but in some localities they are found in great abundance. Fossil Coelacanths are available from the Devonian to the Upper Cretaceous periods, but since the latter period to the present, a period of 70 million years, not much is known of their history. But the presence of living Coelacanths confirms the existence of the fish during the last 70 million years also.

Their disappearance in the Upper Cretaceous may have been brought about by some factor, such as an earthquake, volcanic activity or sudden change in climate. Such changes bring about mass casualities but not total extinction. This explains how the living Coelacanth made history.

M. SUBRAHMANYAM

What is propolis ?

ALSO called bee glue, propolis is a resinous material gathered by bees from the exudations of the buds of certain trees and other vegetative sources. It is a sticky material, yellow to dark reddish brown in colour and possess an aromatic odour.

Composition of propolis

Waxes	30%
Resins and balsam	55%
Ethereal oils	10%
Pollen	5%

Some workers mention two kinds of propolis: one gathered from trees and other vegetative sources: and the other produced probably in the honey sac (within the body of the bee) as a result of pollen consumption. The former is used by the bee for many purposes, while the latter—also called balm—is used to polish every newly built cell before an egg is laid in it. May be, this helps in the disinfection of the interior of the cell.

Propolis is collected by worker bees in a colony. Some species and races of bees collect much more propolis than the others. Similarly, certain areas are richer in propolis sources than the others. However, it has been observed that the collection is influenced more by an unidentified seasonal factor than by the availability of the material.

Within the same locality the propolis is collected early rather than late in the day and is packed, just like pollen, into pollen baskets located on the hind pair of legs of the bee. Being sticky in nature, a bee spends much longer time to collect and pack propolis than it does with pollen. On returning to the hive the bee with the propolis load retreats to a remote part of the hive while the other bees pull pieces off the loads in its leg baskets. Quite frequently propolis collectors may not enter the hive but give off their loads outside on the alighting board.

Propolis sticks to fingers while manipulating the combs in a bee colony but is normally harmless to human skin. However, a few people (about 1 in every 2000 beekeepers) are allergic to it and may suffer from dermatitis. [Its hot water or hot alcohol extract possesses antibiotic properties and remains stable for many months in a refrigerator. It also possesses fungicidal properties.

In the hive it is usually admixed with beeswax and then used to fill cracks and crevices, cover foreign material, polish the inside of the cells, and also to line and smooth off the inner surfaces of the hive. It is also used to join the combs together quite firmly.

On account of its antiseptic properties it is used in various pharmaceutical preparations and serves as the base for antiseptic preparations used by surgeons. It is also highly recommended as a domestic remedy against body wounds and burns. It also finds use in varnishes, including the violin varnish.

Believe it or not, propolis fetches as high a price as Rs. 4500/- per kg in Japan, possibly due to its antibiotic effect.

R.L. ADLAKHA

Why seeds lie dormant

NEARLY all land plants pass through a phase of dormancy at some stage in the life cycle, either as spores, in the lower plants, or as seeds, in the case of higher plants. The phases from germination of the seed to complete maturity of the plant manifest growth and development as a continuous process. Usually the phase of dormancy coincides with a period of unfavourable climatic conditions. Dormancy is typically a phase which shows special adaptation to adverse environmental conditions.

The temporary suspension of growth in normal plants, even under favourable conditions, is termed as dormancy and the tissue involved are known as dormant for that period. Dormancy has been defined as the failure of a perfectly viable and fully ripened seed to germinate even if placed in such conditions that are ordinarily favourable for quick germination and vigorous seedling growth.

Dormancy may be due to a variety of causes, such as extra-hard coats, or the need for a period of internal chemical change known as 'after ripening', the lack of oxygen, the presence of inhibitory substances, or to other reasons. It is often associated with a low water content in the seed but some seeds remain dormant even when lying in a moist medium, like the soil, and fully imbided with water.

Dormancy occurs in many plant parts such as seeds, buds, and even in roots. The seeds of principal crop plants have usually only a short period of obligate dormancy. In case of cereals like wheat, barley, oats, the seeds show a definite dormant period. After dry storage such seeds become capable of germination. In many seeds it may be possible that complete development of embryo has not occurred and so germination will not take place. Some seeds have no dormancy at all and will sprout in damp conditions even before they have been shed.

Many seeds undergo the period of after-ripening successfully in the dry state, but there are others which can do so in the moist state. In all these cases the term dormancy properly applies to that period, which may be short or long, during which the seed is incapable of germination and ends when the seed becomes germinable.

The seeds of wild plants are very variable in their period of dormancy. Seeds capable of prolonged dormancy in the soil usually have impermeable coats and do not absorb water or become germinable until the testa has either been mechanically injured or else has sufficiently rotted to become permeable. Even where this is not the case the seed may have special requirements, such as a period of low temperature or exposure to light, which are needed to render its germination. Dormant seeds are present in most soils to a surprising extent and may remain viable for very long periods. Seeds of the poppy have a remarkably long dormancy and therefore accumulate in the soil year after year. Grass seeds, on the other hand, have mostly only a short period of obligate dormancy.

Seed dormancy presents a problem of considerable economic importance. Dormancy may be over-come by several methods. Scarification, which results in the rupturing or weakening of the seed coats, permit germination; secondly, if seeds after ripening are exposed to low temperatures, they germinate in a short period.

Seeds of many temperate species show a form of dormancy which is overcome by chilling. In some cases dormant embryos may be induced to germinate without chilling, after removal of the seed coats. The dormancy of many seeds with a chilling requirement may be overcome by treatment with various chemicals like nitrates, thiourea, ethylene chlorhydrin, gibberellic acid and kinetin.

The germination of many seeds is affected by light. A large number of seeds show a form of dormancy which is overcome by exposure to light. Apart from this, in some species the seedcoat effects are due to interference with gaseous exchange, especially with oxygen uptake. Thus, certain dormant seeds may be induced to germinate in high concentrations of oxygen.

Dormancy is of immense importance to both man and plant. Thus, in the desert, where water is in short supply the dormancy of seeds of many plants is terminated only by a soaking rain. The dormancy of the potato tubers is evidently of very great value, but for the dormancy storage losses due to untimely sprouting of onions, potatoes, etc., would have been enormous. Dormancy can often be a value to the plant in passing through unfavourable seasons and in allowing time for wide dispersal of seeds.

ARUN KUMAR PANDEY

Are peptides the 'memory molecules'?

THE successful elucidation of the molecular code for proteins stimulated research during the last decade to discover evidence for a similar code for processing acquired information in the nervous system. There have been three main experimental approaches to the problem: detection of chemical changes in brain associated with acquisition of information; impairment of information processing by inhibitors of RNA and protein metabolism; and bioassay methods for testing the information content of material extracted from brain. Particularly, RNA molecules are held by certain investigators as the engram of memory. But it is highly controversial. Should RNAs be regarded as the 'memory molecules' keeping in view the strong counter arguments and lack of adequate experimental evidences which are absolutely necessary to establish this claim (see S.K. Imam, *S. R.* **10**, 178, 1973)?

For the last few years, Dr. G. Ungar and his group in the Baylor

College of Medicine, Houston, Texas, U.S.A. have been deeply involved in establishing some new kind of memory molecules specific for certain behaviours. In 1972, they isolated a substance from the brain of rats trained to avoid the dark, which when injected intraperitoneally into untrained rats, produced dark avoidance (*Nature*, **238**, 1972). On chemical examination, it was found to be a pentadecapeptide whose structure has been confirmed by chemical synthesis. The natural substance and the chemically synthesised peptide were found to be equally potent to induce dark avoidance in untrained rats. The peptide was shown to be absent in the brain extract of untrained rats and was present in very minute quantities in the brain of the trained rats, the yield being 10 to 30 micrograms from 100 grams of brain (one rat brain weighs between 1 and 2 grams). It was named scotophobin (from Greek *skotos*-dark and *phobos*-fear). Scotophobin may be considered to be identified first among the many coded molecules into which information has to be converted for being processed by the nervous system.

In 1969, H. P. Zippel and G.F. Domak (*Experientia*, **25**, 938, 1969) carried out some experiments which showed that goldfish could be trained to avoid either green or red colour. This discrimination could be transferred to naive recipient goldfish by injecting brain extracts of trained goldfish. Unger *et al.* (*Fed. Proc.* **30**, 265 Abs. 1971) confirmed this observation and extended it from green and red to other colours. In a subsequent publication (*Experientia*, **28**, 1026, 1972), they hypothesised the existence of two distinct substances produced in the brain as a result of training the goldfish to discriminate between blue and green. In a more recent report Unger and associates (*Fed. Proc.*, **33**, 464, 1974) claimed to have isolated those specific substances from the brains of 8,000 goldfish trained for each colour. Like scotophobin, these substances are present in very minor quantities in the trained brain and are small peptides in chemical nature. All three peptides are detectable in the RNA extract of the brain, perhaps as dissociable complexes with RNA. Although, it is not predictable at this moment, that all informations in the brain are coded as, or processed through, small peptides the evidences are unique in the sense that they will stimulate the search for other peptides which may serve as 'memory molecules' in particular instances.

B. PAL

LETTERS

(*Continued from page 266*)

intracellular symbionts, derived perhaps from organisms resembling modern bacteria.

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Pantnagar (Nainital)

Soybean

Sir, Soybean, being a recent introduction in India, is not popular among our farmers. Recently, it has attracted attention of our scientists due to its high nutritional value and research is being conducted at many research centres in India.

Soybean seeds are valuable food material due to their high nutritional value, high quality oil and protein content. In foreign countries, its seeds are consumed green, dry or sprouted besides making various products like soy-milk, soy-sauce, cheese, curd, etc. Soy-milk is mainly used for feeding children in China. It contains 3-4% proteins, 1-5% fats and 2% carbohydrates. Commercial byproducts of soybean oil industry include lecithin, oilmeal for live-stock and poultry and also varnishes, paints, ink, etc.

Soyflour is used in bakery, meat industry, icecreams and breakfast foods. One kg. of soyflour is equivalent in protein to 108 eggs or 9 quarts of milk or 1 kg. of beef, and ranks high in proteins as compared to other foodstuff. Due to low starch content, its chappaties are ideal food for diabetic patients.

Chemically, soybean seeds contain 43% protein, 20% oil or fat, 21% carbohydrates, 0.24% calcium, and 0.69% phosphorus. They are also rich in vitamins. Amino acids such as lysine and methionine, normally lacking in vegetable diet, are also high in its seeds. Soybean is therefore a good food supplement for vegetarians.

N.S. DHILLON
Punjab Agricultural University
Ludhiana

NEWS & NOTES

India's first atomic blast

INDIA exploded her first underground nuclear device at 8.05 a.m. on Saturday, 18th May in the sandy tracts of Rajasthan desert. The experiment was carried out as part of the programme of study of peaceful uses of nuclear explosion the government had undertaken to keep itself abreast of developments in this technology, particularly with reference to its use in the field of mining and earth-moving operations. The charge, a plutonium 'implosion' device of 10-15 kiloton yield, was set off at a depth of more than 100 meters. Preliminary studies have indicated that the explosion was totally 'contained' with almost no radioactive venting. According to Dr. H.N. Sethna, Chairman of the Atomic Energy Commission, it would take at least six months to gather, compute, and evaluate the massive data that the explosion was designed to provide.

In the implosion technique several pieces of the fissile material (plutonium) are kept separate within a spherical container. At the moment of the explosion they are suddenly brought together (imploded) by chemical explosive charges (TNT), set peripherally, to form a 'supercritical' mass necessary for spontaneous nuclear explosion. Technically, this technique is more difficult than the projectile method in which a subcritical mass of the nuclear material is fired at a high velocity against another piece of subcritical plutonium. In the resulting impact the two subcritical masses fuse to become super critical and explode. The use of implosion technique is thus indicative of the sophistication that Indian scientists have achieved in the field of nuclear technology.

Plutonium was chosen as the fuel despite the fact that it is extremely toxic and has to be artificially produced (it does not occur in nature) mainly because unlike uranium which has to be 'enriched' by costly processes plutonium can be manufactured in 100 per cent purity in India's existing atomic reactors. In fact, the 20 kg. or so of the element used in the test was entirely indigenously produced.

Underground nuclear explosions have many potential practical applications, specially in mining of non-ferrous metals and tapping of oil from certain geological areas. They can also be used for digging harbours and construction of 'instant dams'. According to indications available, more such tests may be carried out in future to collect vital data.

Biman Basu

Package deal for Indian scientists abroad

THE Government of India has approved a scheme prepared by the Council of Scientific & Industrial Research to attract Indian scientists, technologists and engineers currently employed in responsible positions in Research and Development and manufacturing establishments in foreign countries. The scheme would promote the return to India of those scientists, engineers and technologists who, having completed their studies or research abroad, have taken up jobs in production departments or management positions in industrial firms abroad due to lack of employment opportunities in India.

This package scheme is framed on the lines of the Entrepreneurship Development Scheme presently being operated by the Ministry of Industrial Development. The facilities offered under this scheme would be:

(a) Scientists/technologists who are abroad will be permitted to keep the foreign exchange earned by them in their foreign bank account for a period of 3 years instead of 30 days as at present.

(b) Permission will be given to use this foreign exchange for importing equipment, machinery, capital goods, raw materials, etc. In order to avoid delay, the essentiality and availability certificate from DGTD will be waived.

(c) A simplified procedure will be adopted for (i) licensing, (ii) capital goods clearance, and (iii) issue of an import licence.

(d) CSIR will set up a Bureau to offer advice to the scientist/technologist returning from abroad to match his skills with the local market needs and facilities.

(e) Financial institutions such as IDBI, IFC, State Bank of India, etc., will be requested to extend their present facilities to include entrepreneurial loan on special terms.

The Council of Scientific & Industrial Research will be the implementing agency to the scheme. A Committee under the Chairmanship of the Director-General, Scientific & Industrial Research and Consisting of

(*Continued on page 310*)

MEDICAL NOTES

Vaccine against hepatitis B ?

AN important landmark on the hepatitis frontier was the discovery in 1969 of a specific antigen, called Australia antigen, in the serum of many patients with viral hepatitis (*J. Amer. Med. Assn*, **207,** 1895, 1969). Since hepatitis virus is transmitted through blood as was evident from the increasing number of blood transfusion hepatitis cases, an effective method for the screening of blood and blood products was sought. Partial success was achieved by the timely introduction of Human Anti-Australia antigen serum in 1971 (in the U.S.A.) for the diagnosis of viral hepatitis. Since then, scientists working in this field started looking for an effective vaccine against hepatitis B.

Efforts are currently being directed towards passive and active immunization against hepatitis B infection. Passive immunization, using gamma globulins purified from plasma containing high titre antibody to hepatitis B antigen, has offered some hope although it gives only a temporary protection. Active immunization remains the only possibility of producing an effective vaccine.

Dr. J.S. Krugman of the Willowbrook State School, U.S.A., for the first time showed in 1973 that active immunization is feasible against hepatitis B infections. Dr. Krugman and his associates used as the 'vaccine' a known infective human serum that contained hepatitis B antigen, with some pretreatment (*New Engl. J. Med.*, **288,** 755, 1973). This heat-inactivated serum when innoculated could successfully preve infection in 69% of the children who were exposed after 4 to 8 months to the same strain of hepatitis B virus. The induction and persistance of the hepatitis B antibody by even such crude innoculations were fairly promising, but from the serological point of view heat-inactivated whole serum can hardly be regarded as a satisfactory, or indeed as an acceptable, 'vaccine'. Hence what was needed for an active immunization was a purified preparation of the antigen, or fragment thereof. But the main hurdle that remained to be overcome was the failure to grow hepatitis B virus in tissue or organ cultures.

It is known that a close association does exist betwen Australia antigen and human hepatitis B virus (*Bull. Wld. Hlth. Org.*, **42,** 957, 1970). A close look at the morphology reveals some common features between the two. The principal antigenic constituent exists in more that one shapes, e.g., spherical, tubular, spheroidal, etc., together with different sizes. The spheroidal antigenic particle is known as "Dane particle". It measures about 42 nm (1 nm 10^{-9} m) in diameter with an inner core of about 28 nm in diameter. It has a 2 nm shell and an outer coat about 7 nm in thickness. Detergent treatment of this particle splits it into an outer coat of antigen and an inner component which is 28 nm in diameter (*Lancet*, ii, 1225, 1971). Quite interestingly, it was found that antibodies present in the serum of patients who have recuperated from the hepatitis B infection reacted with the inner component, but not with the outer antigenic component. Antibodies to the inner core was, however, found to be absent from the pre-hepatitis sera. This led to the belief that antibodies to hepatitis B antigen develops during the course of infecton and clears off with the clinical improvements, while the normal immune response is produced to the inner core of the Dane particle. It has also been observed that isolated viral coat protein behaves in the same way as the whole infectious agent. So it appears that it is the outer component that carries the actual antigenic determinant while the inner component represents the infectious entity. Therefore the possibility of using purified hepatitis B antigenic particle which are free of nucleic acid, and hence of infectivity, seems tempting.

Further studies on Australia antigen reveals that this unique antigen represents incomplete viral particles in the form of aggregates of protein subunits or excess viral coat protein. Subunits of the antigen, in the form of small polypeptide, on the other hand, offer a much attractive proposition as immunogens. Recently K.R. Rao and G.N. Vyas of San Francisco, U.S.A. (*Nat. New. Biol.*, **241,** 240, 1973) have been able to prepare active subunits of hepatitis B antigen by sonication and chromatography. This may provide a basis for the development of a synthetic peptide which when coupled to human albumin could serve as a suitable immunogen. Such polypeptide preparations have to be investigated as potential vaccine for hepatitis B by defining the immunogenic moeity through studies in appropriate non-human primates (*Nature*, 237, 517, 1972).

Complete elucidation of the structure of Australia antigen in near future will surely provide a stronger basis for the vaccinotherapy of hepatitis B.

S.N. SINHA
DIPAK K. DUBE

(*see also page 308*)

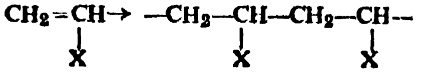
SCIENCE FOR THE YOUNG

Are we surrounded by macromolecules?

THE term molecule is defined as the combination of two or more atoms held together by chemical bonds. Simple molecules like NaCl, KCl, etc., play their valuable role for sustenance of life. It may sound strange that the majority of substances which we come across in every day life are not simple molecules but are giant molecules or 'macromolecules' having molecular weights of the order of several thousands. This is equally true for the materials inside our bodies also. Nylon, terylene, polystyrene, polyethylene, etc., are examples of synthetic macromolecules while natural polymers include rubber, resins, gum, proteins, starch, cellulose, etc.

Macromolecules are formed by the process of polymerization. Polymerization may take place either by condensation or addition reactions. Condensation polymers are usually formed by stepwise intermolecular (i.e., between two molecules) condensation of reactive groups while addition polymers result from reaction involving some sort of active centres. In the condensation polymerizaton the molecular formula of repeat unit of the polymer chain lacks certain atoms present in the monomer from which it is formed. Usually water is split out as the monomer units join together. The synthesis of nylon from hexamethylene diamine and adipic acid proceeds by this reaction.

Addition polymers are those in which no loss of small molecule take place. The most important group of addition polymers include those derived from unsaturated vinyl monomers, e.g.,



$$CH_2=\underset{X}{CH} \rightarrow -CH_2-\underset{X}{CH}-CH_2-\underset{X}{CH}-$$

Butadiene molecule with molecular weight of 54 polymerizes to form polybutadiene with molecular weights as high as 5 to 6 million.

The repeat unit of a polymer is usually equivalent or nearly equivalent to the monomer from which the polymer is formed.

Biological macromolecules

The world of living things is made up of a great variety of chemical substances, many of which fall in the category of macromolecules. We

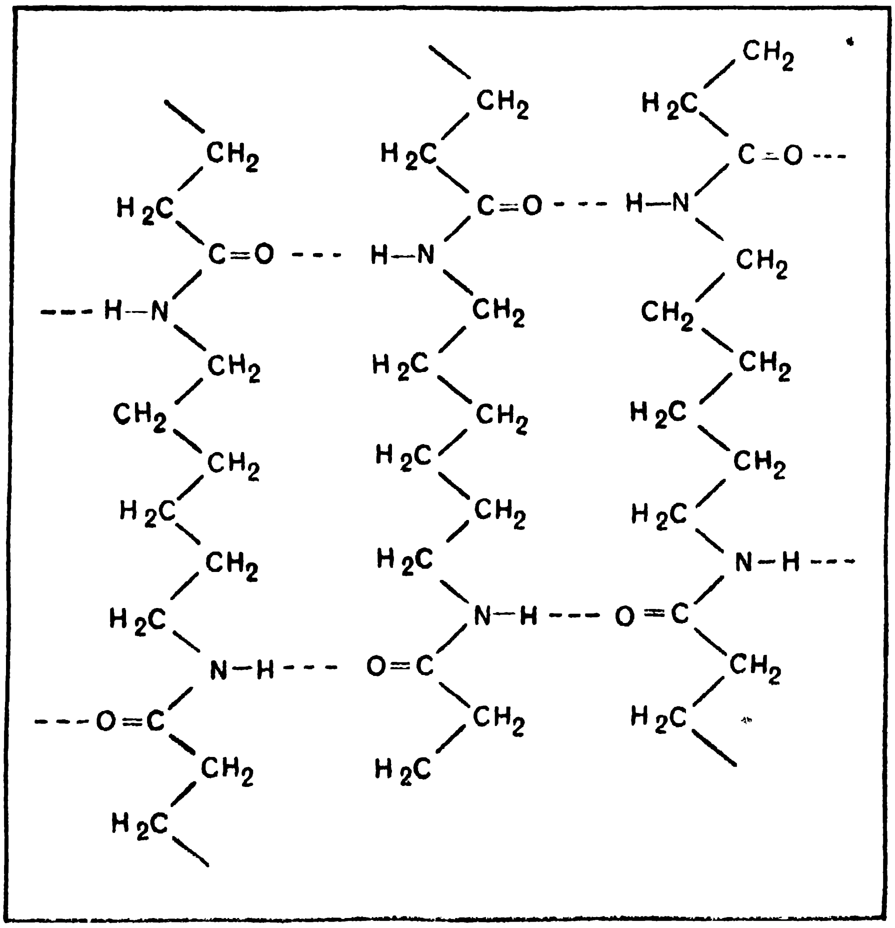


Fig. 1. Molecular structure of Nylon

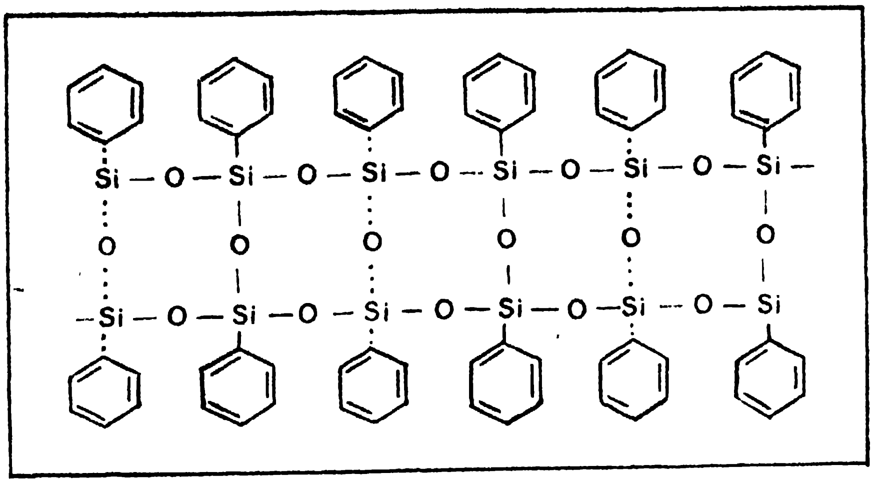
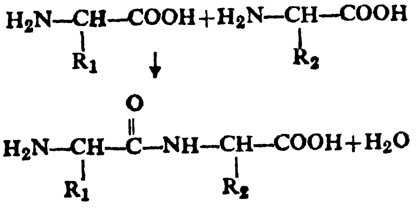

Si — O — Si — O — Si — O — Si — O — Si — O — Si —
O O O O O O
—Si — O — Si — O — Si — O — Si — O — Si — O — Si

Fig. 2. A silicone polymer

shall discuss biological macromolecules in connection with what presumbly constitute life itself.

The building blocks of biological systems are proteins, carbohydrates, nucleic acids, lipids, etc. The proteins can be broken down by hydrolysis to yield organic molecules, all of which are amino acids. The attachment of one amino acid to another is through a peptide bond. The condensation of two amino acids can be depicted as:



$$\underset{\displaystyle R_1}{H_2N\text{—}\overset{}{CH}}\text{—}COOH + H_2N\text{—}\underset{\displaystyle R_2}{CH}\text{—}COOH \;\downarrow\; H_2N\text{—}\underset{\displaystyle R_1}{CH}\text{—}\overset{\displaystyle O}{\overset{\|}{C}}\text{—}NH\text{—}\underset{\displaystyle R_2}{CH}\text{—}COOH + H_2O$$

By repetition of such a reaction amino acids can be built up into macromolecules. There is a definite sequence of number of different amino acids in a protein which continues throughout the protein molecule.

Nucleic acids occur in two main types, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA consists of two macromolecular chains that are linked together by hydrogen bonds. The molecular weights of most forms of DNA are still uncertain. However current estimates based on physical measurements give values between 1 to 10 million. The average molecular weight of RNA is of the order of 10 thousand.

The third important type of biological macromolecules is the polysaccharides. They consist of large number of chains of simple sugar molecules joined by glycosidic linkage. They have molecular weights as high as 10 million. Among the polysaccharides of wide occurrence is amylose, the major component of starch. This is essentially a storage form of glucose found in plant cells. Its counterpart in animal cell is glycogen. Other polysaccharides which are found in nature include cellulose that occurs in plants.

Although the fatty lipid molecules are not in themselves macromolecules, the polar lipids in water form large liquid crystalline groups containing thousands of molecules. In a sense, therefore, the polar lipids may also be considered to behave as a macromolecule.

Macromolecular nature of clothing

For our clothing we use the natural fibres that include silk, wool and cotton and the synthetic fibres such as nylon, terylene, etc.

Silk is a polypeptide made up of only four amino acids: glycine, alanine, serine and tyrosine. It has been valued for thousands of years for its strength, toughness, smooth and soft feel. Glycine and alanine present in 2:1 ratio account for 75% of the material.

Wool is a complex polypeptide, a polyamide made up of about 20 amino acids. Wool can exist in both the α-and β keratin structures (characteristic of polypeptides),. helical, and extended sheet structures respectively. About the half of wool's mass is in main polymer chain and half in side chains.

Cotton is about 95% cellulose with small amount of protein, pectin, and wax. Cellulose is a polysaccharide made up of β (D+) glucose residues joined in linear chains. With its three hydroxyl groups cellulose has the probability of forming many hydrogen bonds. The highest molecular weight cellulose is found in cotton which is the best source of pure cellulose. Molecular weights as high as 570,000 are found corresponding to a degree of polymerization of 3500. The molecular weight of cellulose from wood and other sources is considerably lower.

Among the synthetic fibres, terylene was discovered by J.R. Whinfield and J.T. Dickson in 1940. The fibre is made up by polycondensation of polyethylene terephthalate which is condensation product of terephthalic acid and ethylene glycol.

Nylon 66 is the condensation product of adipic acid and hexamethylene diamine. The possible linking of chains is shown in Fig. 1.

Macromolecules of medicinal use

There are a number of macromolecules which are used in one way or the other for medicinal purposes. A research institute in the U.S.A. has developed a synthetic polymer as an artificial skin, specially for burn injuries. The polymer may also be used as membranes for artificial kidneys. For artificial skin the polymers are cast as films which are the copolymers of two amino acids having molecular weight of about 50,000.

The use of polyethylene is frequently made in heart valve, stomach wall-support as well as for preparation of tubings and syringes. Nylon is used for blood transfusion sets, syringes and vascular implants. Silicones are being used in plastic surgery, heart valves and in urethral valves. Artificial cornea and substitutes for bones are the outcome of polymers of fluoro-carbon groups. The use of polycarbonates for baby bottles and of acrylics for adhesives are of no less importance. Attempts are in progress to duplicate the natural hormone, insulin, and other large, complex, biologically active protein molecules.

Miscellaneous applications

With the advancement of technology there is a growing need for temperature resistant materials. The organic polymers based on carbon cannot meet this demand particularly because they melt easily. One way in which high temperature properties has been created in organic polymers is by stiffening the chains with addition of ring structures, cross linking the chains, and by inducing crystallisation. Such polymers are generally called ladder polymers (Fig. 2).

The other had been the development of inorganic macromolecules. Macromolecules containing silicon-oxygen chains are collectively known as silicones. Silicone oils, grease, rubber polish, etc., are the examples of this type.

Silicon-nitrogen, phosphorous-nitrogen and boron-nitrogen chains under suitable conditions may also give inorganic linear polymers. For example, phosphonitrilic chlorides having nitrogen-phosphorous linkage are compounds of polymeric nature. Some of the highest polymers are elastomeric in their properties (i.e., they behave like elastic).

So, we find we are living in a world dominated by macromolecules. With the advancement of technology we can expect even better role of these big molecules in our daily life.

P.C. SHUKLA

MEDICAL NOTES *(Continued from page 305)*

Vinyl chloride causes liver cancer

VINYL chloride, the foundation chemical for hundreds of plastic products, has recently been linked to the development of a rare fatal liver cancer in industrial workers who handled this monomer during its polymerization into polyvinyl chloride. So far, 12 workers in the U.S.A.—all of whom had many years of exposure to the chemical—have contracted the cancer, called angiosarcoma of the liver. In an attempt to find the truth of this observation, the Manufacturing Chemists' Association recently conducted a study that indicated that when mice were exposed to the amount of the chemical that the workers are currently exposed or permitted to inhale, the animals developed liver cancer. At present. the U.S. Federal emergency occupational standard of 50 parts of vinyl chloride per one million parts of air (ppm) is termed safe. At this level of exposure for 7 hours a day over 7 months, several mice in the study had developed angiosarcoma of the liver (*New York Times*, April 16, 1974).

The U.S. Environmental Protection Agency (EPA) recently announced that it would begin a study to determine what happens to the more than 150 million kg. of vinyl chloride that escapes into the environment each year in the process of manufacturing plastics. Although there is no evidence to date that vinyl chloride, an odoriferous gas, represents a hazard to the general public, there is considerable concern among public health officials, because vinyl chloride is used as a propellant in some aerosol consumer products, including hair sprays and pesticides. An EPA study of vinyl chloride exposure resulting from the use of an antiseptic room spray containing chloride indicated that if sprayed for 30 seconds in a typical bathroom, levels of vinyl chloride in the room air would reach 400 ppm. In the U.S.A. where some 25 companies make about 50 vinyl chloride-containing consumer products, some manufacturers have already withdrawn their hair sprays containing vinyl chloride from store shelves.

BHAKTI DATTA

SCIENCE IN INDUSTRY

Improved process for tamarind kernel powder

TAMARIND kernel powder (TKP) obtained from the seeds of *Tamarindus indica*, a common tree of India, is an important industrial gum and finds extensive use as a sizing material. Large quantities of TKP are being exported to Italy, Japan, Canada, the UK and USA. TKP contains carbohydrates (65-72%), proteins (17-20%), and fat (6-7%).

TKP generally obtained by the pulverization of dehusked seeds has certain inherent defects, namely, a creamy colour, presence of testae (seed coat) and fatty oils, which make it inferior to other cereal starches in the sizing industry. Because of its creamy colour, the solution of TKP is also coloured, and because of the presence of fat, lump formation of the powder occurs and hence it cannot be stored for a long time. Because of the presence of testae the size is not uniformly smooth.

Scientists at National Botanical Gardens, Lucknow, have developed a new process by which it is possible to obtain a product free from these defects so that it is as good as other starches. The product has good keeping quality and higher viscosity. The process is simple and does not require complicated machinary. It consists of treatment of the kernel with an appropriate amount of a decolorizing agent and subsequent treatment with an organic solvent for a few hours before the final pulverization.

A new catalyst for anthraquinone

ANTHRAQUINONE is an important intermediate used in the manufacture of various dyestuffs such as alizarin and indanthrene. It is manufactured in India either by the liquid-phase oxidation using chromic acid or by the Friedel-Craft's route using benzene and phthalic anhydride. The present production falls far short of the annual requirement of about 3000 tonnes.

Scientists at Central Fuel Research Institute, Dhanbad, have developed a new catalytic process for the manufacture of the chemical. The novelty of the new invention lies in the preparation of an improved catalyst. Specially processed silica gel is used as the catalyst support. The catalytically active components and modifiers are then deposited on the processed silica gel and further processed to give a highly selective catalyst. The catalyst is used for the production of anthraquinone by the vapour-phase oxidation of anthracene.

The treatment of the silica gel support is an essential step in the preparation of the improved catalyst. The gel is treated with dilute nitric acid or hydrochloric acid and warmed in a water-bath at 80-90°C for 10-15 hr. The gel is next washed free of acid and dried at 110° C.

The silica gel support is impregnated with a solution containing appropriate quantities of chromium nitrate, ferrous ammonium sulphate, nickel nitrate, cobalt nitrate and potassium sulphate. The mixture is kept heated on a water bath for slow deposition of the salts on the gel. After evaporation to dryness, it is further dried at 105-110° C.

The impregnated silica gel is heated in a muffle furnace at 450-550° C for 4-5 hr. The properties of the catalyst are profoundly modified by subjecting it to thermal treatment at 600-1000° C for 3-4 hr. The procedure for thermal treatment of the catalyst is designed to confer good selectivity and long active life. The finished catalyst can be used in a fluid bed or a static bed reactor. In the process, air is passed at a fixed rate from a blower into the reactor through a pre-heater. Part of the air is bubbled through molten anthracene in a container. The air-anthracene mixture is pre-heated and comes into contact with the catalyst in the reactor and gets oxidized to anthraquinone. Small quantities of phthalic anhydride, maleic anhydride, carbon di-oxide, carbon monoxide and water are also formed.

A series of condensers and bubblers trap the anthraquinone and other products. The yield of anthraquinone is 90-100% per pass of anthracene.

Hand operated bellow pump

A HAND operated bellow pump has been developed by scientists of the Regional Research Laboratory, Bhubaneswar, for pumping water upto a head of 6 metres, ideally suitable for irrigaton. In this pump, pumping action is obtained through compression and expansion of a polythene bellow operating inside a cylindrical casing fitted with suction and discharge valves. During compression and expansion operations, the below moves with wall clearence and as such the sliding frictional resistance as present in conventional piston-cylinder reciprocating pumps is absent and hence contributes to higher efficiency. The absence of piston and cylinder and hence the absence of matching contact does not require machining accuracy for the casing. The use of polythene bellow, of thin wall casing and of polythene valve parts reduces the weight of the pump assembly for transportation purposes. Light weight, low cost of production, ease of manufacture and high efficiency are the principal advantages of the pump.

NEWS AND NOTES

(Continued from page 304)

representatives of the Ministry of Finance, Ministry of Industrial Development, Directorate General of Technical Development, Department of Science & Technology, the Indian Investment Centre and CSIR has also been set up to advice on its implementation.

The Indian scientists abroad may send proposals which if accepted will be given the necessary package assistance. They may contact the Indian Embassy and Chief (Technology Utilisation), CSIR for further details for processing his proposal.

Mariner 10 pictures of Mercury

BEGINNING on March 23, 1974 Mariner 10 photographed the planet Mercury and transmitted until April 3 more than 2000 television frames from its twin high-resolution cameras from a distance ranging from 5,400,000 km. to 3,500,000 km. from the planet. The brief description and the preliminary interpretation of the close-up pictures of this previously unexplored planet have just been reported. According to Dr. Bruce C. Murray of California Institute of Technology at Pasadena and his co-scientists, the major land forms on the Mercury are basins, craters, scarps, ridges and plains, and morphologically these features strongly resemble analogous land forms on the moon (*Science*, **184**, 459, 1974). It was revealed that where the plains were absent, overlapping craters and basins formed rugged terrain. These scientists believe that the materials of the plains have many of the characteristics of the lunar maria and have been cratered to approximately the same degree. This two-fold division of the surface of the Mercury was strikingly similar to that of the moon. The scientists also believe that the largest basin observed on the Mercury has many of the characteristics of the lunar imbrium basin. Numerous smaller basins were also evident, grading from sharply defined to barely discernible; some had two concentric rings. Craters ranged in size. The photographs also revealed the presence of extensive ray systems around bright craters. As on the moon, there was a local source of volcanic material, the scientists suggested. Numerous wrinkle ridges similar to those on the lunar maria had formed within the plains. A volcanic origin for much of this material was also suggested. A prominent difference in structural features on the Mercury and on the moon was that the former had irregular scarps which were up to 1 km. high, extended for hundreds of km. and cut across large craters and inter-crater areas.

R.K. DATTA

BOOK REVIEWS

(Continued from page 311)

agriculture and biology. The use of tracers in study of plant metabolism and hydrology, irradiation studies on mutation, food preservation, radiation sterilization of insect pests, etc., are some of the topics discussed. In the last chapter, on nuclear analytical techniques, the application of activation analysis in biological assays has been described in considerable details.

Although meant primarily for biologists and agriculturists, the book will appeal to any reader interested in knowing about the mysterious world of atoms and isotopes.

BIMAN BASU

BOOK REVIEWS

ENERGY AND POWER, Scientific American Book, *W.H. Freeman and Co.*, 660, Market Street, San Francisco, California 94104, USA, 152 pages, $6.50.

THE exploitation, exploration and the artful manipulation of energy has been an essential component of man's ability to survive and to develop society. The investment of energy in hunting and food gathering has provided man's livelihood for more than 99% of human history. Over the past ten millenia the hunting people transformed themselves into farmers mainly by investing energy in agriculture. From this stage man proceeded further to utilise solar energy, to control and tame his gardening, crop raising, domesticating of animals and manipulation of forestry to arrive finally on the road leading to the complex social structure of today. With industrialisation setting in, the flow of energy has been slowly getting unbalanced. Today we have reached a stage when there is shortage of power, a frantic search for new sources of energy and fuel, and the growing realisation of the dangers inherent in the waste products of all currently feasible energy and power-producing systems.

To present the energy consumption of civilisation in a long term perspective, the Editors of *Scientific American* invited leading authorities to project their valuable thoughts and experience on the subject. The result is a fascinating perspective of the past, present, and the future of energy and power consumption for mankind. Handsomely produced, lucidly written, and copiously illustrated with drawings, charts and photographs, this work should remain an authoritative source of reference for power planners, scientists, technologists and students of history. The first four articles examine the impact of energy on the spectrum of human life; the flow of energy on the earth as maintained through a delicate balance among gravitation, nuclear reactions and radiation: the various energy resources such as solar, tidal, geothermal, and fossil fuel, and the flow of energy in the biosphere including photosynthesis. In the next three articles the reader is presented with thought-provoking discussions on the flow of energy in the hunting society typified by an all-Eskimo settlement along the northern coast of Boffin Island near Greenland (63° to 65° N Latitude); the use of energy in an agricultural society as studied in New Guinea with an interesting moral for modern agriculturists, and the use of energy in an industrial society typified by USA which, with 6% of the world's population, uses 35% of the world's energy. The last four articles deal with energy conversion from light bulbs to gas turbines, the geography of energy distribution with its intricate web of networks; use of energy in information and communication systems with basic data on muscle power, entropy and a list of electronic systems; and decision making in the production of power.

The book ends with short biodata of authors whose back-ground range from natural science, electrical engineering and geophysics, to botany, authoropology and law. A good bibliogrpaphy and an index round off this large 140 page publication on the most significant and potent component of man *viz.*, Energy. It is a *must* on the bookshelf of every intelligent *homo sapien*.

S.K. GHASWALA

FUNDAMENTALS OF NUCLEAR SCIENCE With Applications in Agriculture and Biology by P.N. Tiwari, *Wiley Eastern Pvt. Ltd.*, New Delhi, 1974, Pp. xii+186, Rs. 24.00.

RADIOACTIVITY, discovered more than six decades ago, now plays an important part in our everyday life. Artificially produced radioactive isotopes, made available through the use of nuclear reactors, have proved extremely valuable not only in the science laboratory but also in such practical areas as medicine, agriculture, and industry. The present book covers mainly the applications of radioisotopes in agriculture and biology.

In the first part, the basic concepts of nuclear science the structure of atom and its nucleus, the nature of radioactivity, interaction of nuclear radiation with matter, etc., are discussed in a simple, straightforward manner. The author has avoided any complex mathematics in explaining the various concepts, yet they are at once clear and comprehensible.

In the same section are discussed the various units of radiation dose and the techniques and instruments used to measure them, again from strictly practical point of view. The concluding chapter of the section deals with radiation protection – a vital part of any radiation work. It gives, in plain manual style, the do's and dont's of radioisotope handling. It tells about the use of film badges, ion chambers and pocket dosimeters in monitoring radiation exposure and gives useful tips on how to decontaminate in case of an accidental contamination.

Part II of the book deals with applications of nuclear science in

(*Continued on page 310*)

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OBJECTIVE GUIDE

FOR MEDICAL ADMISSION TEST OF A.I.I.M.S., DELHI, VARANASI, WARDHA, C.P.M.T. OF U.P., A.F.M.C. POONA, VELLORE, PONDICHERRY, BIHAR, M.P., ANDHRA, ORISSA, BANGALORE, MYSORE & MEDICAL COLLEGES OF OTHER STATES. ONLY GUIDE TO CONTAIN TEST QUESTIONS OF A.I.I.M.S., VARANASI, WARDHA & BIHAR. REVISED AND WRITTEN BY DR. N. AHSAN, PROF. N.N. SINHA, PROF. B.K. SINGH, & PROF. S.N. SHARMA OF SCIENCE COLLEGE, PATNA. CONTAINS SYNOPSIS & 10,000 OBJECTIVE & THOUGHT TYPE QUESTIONS BASED ON PREVIOUS TESTS. MAXIMUM QUESTIONS TALLIED IN PREVIOUS TEST. NO QUESTION WILL ESCAPE FROM THIS BOOK. AVAILABLE WITH LEADING BOOK - SELLERS OF INDIA.
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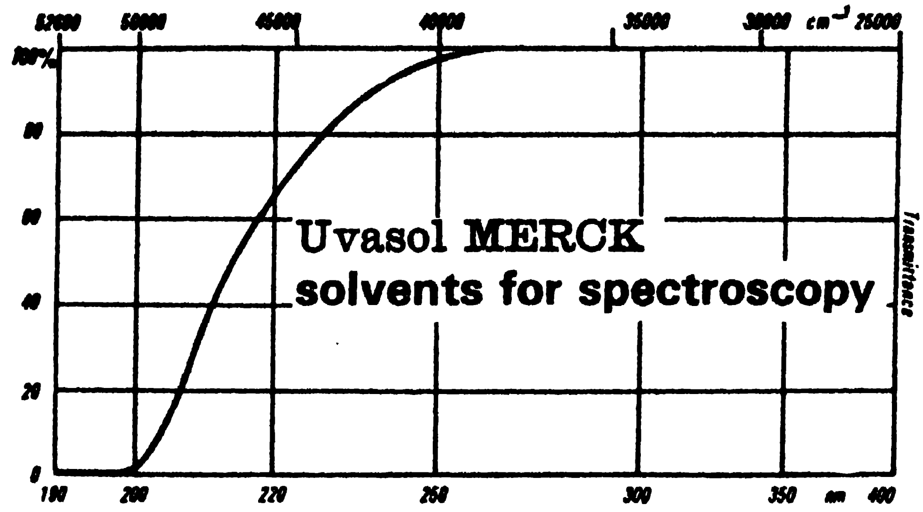

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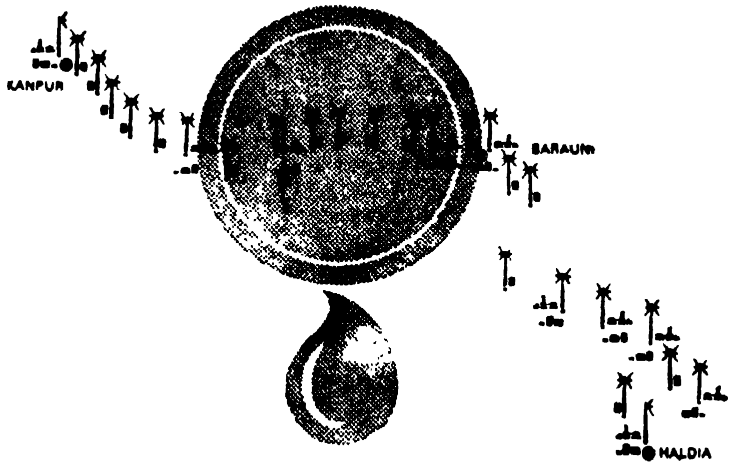

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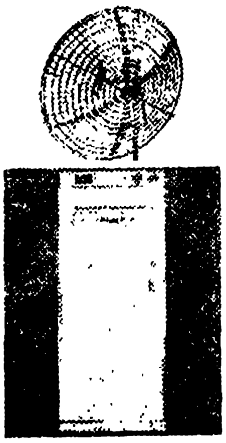

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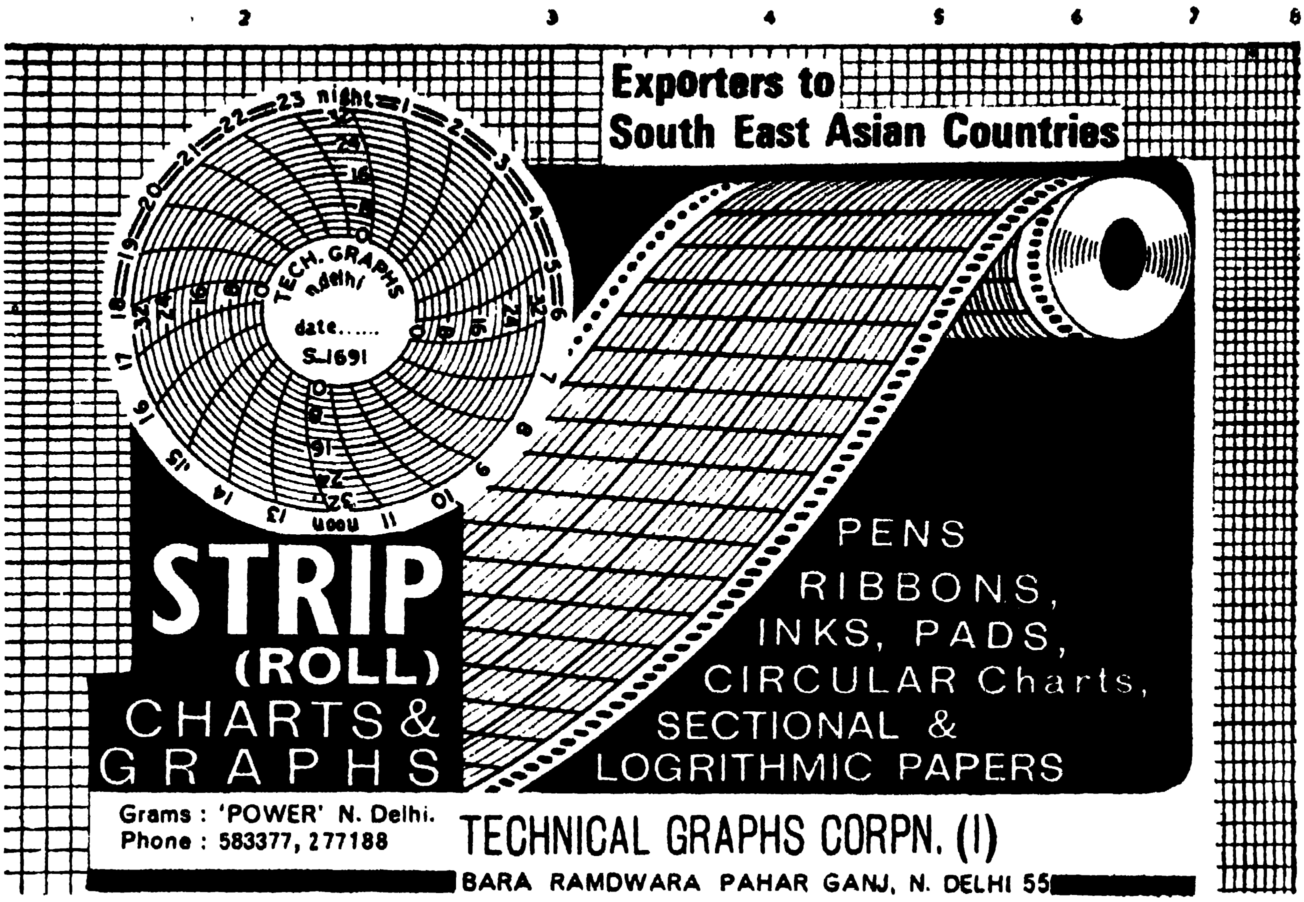

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- The article should preferably be illustrated; captions and legends typed separately and attached at the end of the article. Photographs should be on glossy paper.
- While quoting names of scientists, etc., their initials, nationalities and periods of research under reference should invariably be mentioned.
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COVER

Bird's-eye-view of the *Jantar Mantar* at Delhi, built by Raja Sawai Jai Singh II of Jaipur in 1723
(Photo : *Courtesy.* PIB)

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LETTERS

Fibrin-stabilising factor

Sir, Joydev Mukherji in his letter regarding clotting factor ascribed factor "XII" as fibrin-stabilising factor (*S.R.* November, 1973). It is not correct. Factor XII, which is also known as Hagmeman factor, is an important factor in blood clotting through an intrinsic pathway which in turn is helped by factors XI, IX, X, VIII and phospholipids. Factor XII is activated by contact. There is, however, an extrinsic pathway of clotting where 'contact activation' is not at all required.

In the presence of tissue thromboplastin, factor VIII is activated and later on leads to common pathway for clotting which requires factors V, X, prothrombin, fibrinogen and factor "XIII" or fibrin-stabilising factor. Factor XIII or fibrin-stabilising factor is essential for formation of stable fibrin polymer. In other words, it converts unstable fibrin polymer to stable fibrin polymer and hence a firm clot.

Dr. Amar Lal Dave
Dr. S.N. Medical College
Jodhpur

Operator gene

Sir, I thank you for publishing the article entitled 'How genes are controlled' by P.K. Gupta (*S.R.* December, 1974).

1. Is there any evidence regarding the actual size of an operator gene?
2. Could the rate of the repressor gene function be altered by any factor?

Anjali Ghosh
Dept. of Zoology
University of Kalyani (W.B.)

1. The size of operator gene varies in different operons but it is much smaller than structural genes. In 'lac' operon, Muller-Hill proposed a sequence of 8 base pairs for each of the four sub-units of repressor, thus making a length of 32 base pairs. The actual size and base sequence is still not known.
2. In 'lac' operon, rate of regulator gene's activity is not controlled. However, in α-phage, the activity of regulator genes is controlled in a very intricate manner by a number of other genes and by the repressor itself.

Dr. P.K. Gupta
Reader in Genetics
Institute of Advanced Studies,
Meerut University

Helium

Sir, I read the interesting article "The mysterious liquid helium" (*S.R.* April, 1974) by N.K. Agrawal. The author has said that superconductivity in metals is shown at "the boiling point of liquid helium or *below*". But there are a few metals which are superconductive above the boiling point of liquid helium (*i.e.*, above 4.216 K) too. For example, lead shows superconductivity at 7.22 K and columbium at about 9 K.

Pranesh Misra
Delhi University

Spawning in fishes

Sir, Re: "Fish breeding with hormones" (*S.R.* May, 1973) by Dr. Sundararaj, I would like to know the following:

1. Does the pituitary gland secrete gonadotropic hormones during old age? If so, what are its activities at that time?
2. What are the actual chemical reactions taking place in the target organs (say, gonads) by the hormones?
3. What are the influences of artificial mechanisms for spawning on the life-span and the aging process of fishes?

B. Behera
Sambalpur University, Burla

1. Senescence in fishes is characterized by a slowing of growth rate, increase in mortality rate and a gradual loss of reproductive capacity. Thus gonadotropic activity of the pituitary, like other tissues in the body, also undergoes senescence.
2. Gonadotropic hormones, like other hormones, first attach themselves to a receptor protein present in the cell membrane of the target gland. Some hormones activate the enzyme adenyl cyclase present in the cell membrane, which converts adenosine triphosphate (ATP) to cyclic 3′, 5′—adenosine monophosphate (cAMP) which in turn acts as a second messenger. Recent evidence shows that some hormones may involve cyclic guanosine monophosphate (cGMP). The messenger (cAMP) or (cGMP) activates an enzyme, protein kinase, which in turn may activate another enzyme phosphorylase kinase to bring about phosphorylation responsible for the manifestation of the action of hormones.
3. Fishes artificially induced to spawn should theoretically live as long as, if not longer than, their counterparts in nature. There are many instances where the life-span of fishes has been prolonged in captivity.

B.I. Sundararaj
Prof. of Zoology
Delhi University

Cellular defense

Sir, I have gone through 'Virus and cellular defence' (*S.R.* March, 1974). In this article the authors have mentioned that, "..how this antiviral protein prevents viral multiplication is still not well understood."

Recently, Glasky and his associates (*Science*, **144**: 1581, 1974) have shown that in cell-free preparations, interferon inhibits an RNA-synthesizing enzyme found in cells infected with an RNA virus. The formation of this enzyme, which they call RNA-synthetase, may be a critical step in successful replication of RNA viruses, and their inhibition (by interferon) would be expected to prevent the synthesis of new virus particles.

DR. SAMAR CHAKRAVARTI
M.B.B. College
Agartala, Tripura

Mental disorder

Sir, I am writing with reference to Dr. Raj Shankar's article on "Chemical clues in mental disorders" (*S.R.* May, 1974).

While correlating the decreased serotonin content and sedation, I wonder how the author has failed to mention the well-known disease 'Migraine' which is also caused by a drop in brain serotonin content. Defective or unstable turnover of seretonin in certain specific areas of the brain results in migraine. Sicuteri and his colleagues have proposed (*Psychopharmacologica*, Vol. 29, p. 347) that serotonin acts as a 'physiological blockade' in spreading painful impulses to other parts of the brain during normal situation.

G. M. NATARAJAN
Shri Pushpam College
Thanjavur, Tamil Nadu

Nutritive value of proteins

Sir, I have read with great interest R. Krishna Rao's article on 'Nutritive value of proteins' in May 1971 issue of *S*.R.

I wish, however, to refer to certain statements and remarks in the article that are not correct. The author has mentioned that all proteins on hydrolysis give 22 amino acids. Then what about proteins like parathyroid hormone, glucagon, insulin, etc., which do not contain all the 22 amino acids ?

Further, the author has forgotten to mention arginine and histidine in the essential amino acid list. However, the former can be synthesised by the rat but not at a sufficiently rapid rate to meet the demands of maximum growth. Its classification, therefore, as essential or non-essential is purely a matter of definition.

Finally, the amino acids which are not utilised in tissue protein synthesis are eliminated not only through urine but also through sweat.

K. MUNIYAPPA
Dept. of Biosciences
Mangalore (*Karnataka*)

Aflatoxins

Sir, I have read the article "All about aflatoxins" by K.R. Natarajan (*S.R.* March, 1974) which was quite useful, as most of the basic things have been covered. I would like to know the names of the Indian scientists who have developed new varieties of peanut which exhibit considerable resistance against mold growth and also the names of the peanut varieties with code number, if any.

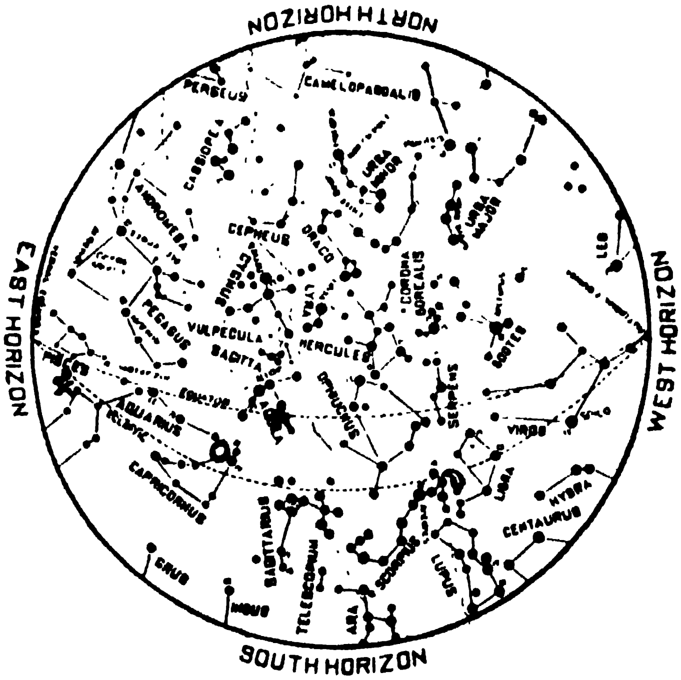
S.H. KADADI
Worli, Bombay

Development of peanut varieties which would resist aflatoxin-producing molds or which would inhibit production of aflatoxin by them is still in its infant stage. No aflatoxin-resistant peanut variety is commercially available to farmers in the world. Research carried out in India and the U.S.A. has shown that some peanut varieties possess some degree of tolerance to mold growth or aflatoxin production. A varietal difference in the production of aflatoxin in peanuts inoculated with *Aspergillus flavus* was first reported by Suryanarayana Rao and Tulpule (National Institute of Nutrition, Hyderabad) in 1967 (*Nature*, **21**, 738; 1967). In the same year Kulkarni, Sharief and Sarma reported that the red-seeded Asiriya Mwitunde was tolerant to aflatoxins (*Indian Farming*, **17**, 9:1967). However, Doupnik (USA) reported that of two aflatoxigenic isolates of *A. flavus* he used to test for inhibition of aflatoxin production on two cultivars of Asiriya Mwitunde (P.I. 268893 and 295170) and a U.S. cultivar (P.I. 246388), both produced substantial levels of aflatoxins. The differences in results were ascribed as possibly owing to certain cultural practices or some unique characteristics of the *A. flavus* isolates or both. Recently Mixon and Rogers (USA) who evaluated more than 1200 breeding lines or varieties of peanuts for seed invasion by *A. flavus* reported that Kabeka (P.I. 346388), and Asiriya Mwitunde (P. Is, 268893 and 295170) previously reported to be resistant to aflatoxin development by different researchers in Hyderabad were susceptible to invasion by *A. flavus* (*Oleagineux*, **28**, 85, 1973). The two resistant lines, P.I. 337139F and P.I. 337400 are not suitable for commercial cultivation in their present form. They are Valencia type. Troeger (USA) reported that a striking difference exists among three varieties (Starr Spanish, Early Runner and Florigiant) in susceptibility to aflatoxin contamination (*Oleagineux*, **25**, 213; 1969). Very recently Nagarajan and Bhat (National Institute of Nutrition) confirmed that there are species and varietal differences in toxin production (*Applied Microbiology*, **25**, 319, 1973).

It is not clear why certain varieties of peanuts support low toxin production whereas other varieties support maximal production. Research directed toward identifying and developing peanut lines with resistance to aflatoxin producing molds is continuing in India and U.S.A.

K.R. NATARAJAN

PLANETS AND THEIR POSITIONS—AUGUST 1974



PLANET
♃ - JUPITER

MAGNITUDES
-1 0 1 2 3 4 5
◆ ● ● ● • • .

MOON
O - FULL MOON-3rd
☽ - FIRST QUARTER-24TH

The Moon

Full moon on 3rd at 9-27 a.m and new moon on 8th at 0-32 a.m. I.S.T.

The moon passes about seven degrees north of Jupiter on 6th, two degrees south of Saturn on 15th, and four degrees south of Venus on 16th. The lunar crescent becomes first visible after the hew moon day in the evening of 19th.

The moon is at apogee or farthest from the earth on 3rd and again on 30th and at perigee or nearest to it on 17th.

The planets

Mercury (Budha), a morning star, rises about an hour before sunrise during the first quarter of the month. Thereafter it is too near the sun to be visible, being in superior conjunction on 17th. It passes about seven degrees south of the star Pollux (*Punarvasu*) on 2nd. It moves from Gemini (*Mithuna*) to Leo (*Simha*) through Cancer (*Karkata*). Its visual magnitude varies from —0.7 to —1.3.

Venus (Sukra), a morning star, rises about two hours before sunrise during the first half of the month and about an hour before it during the second half. It passes about seven degrees south of the star Pollux (*Punarvasu*) on 10th. It moves from Gemini (*Mithuna*) to Cancer (*Karkata*). Its visual magnitude is about —3.3.

Mars (Mangala) sets about an hour after sunset during the first half of the month after which it is too near the sun to be visible. It is in Leo (*Simha*). Its visual magnitude is about +2.0.

Jupiter (Brihaspati) rises about two hours after sunset during the first half of the month and about an hour after it during the second half. It is in Aquarius (*Kumbha*). Its visual magnitude is about —2.4.

Saturn (Sani), visible in the morning sky, rises about two hours before sunrise during the first half of the month and about three hours before it during the second half. It is in Gemini (*Mithuna*) Its visual magnitude is about +0.4.

(*Source*: Nautical Almanac Unit of the Meteorological Office, Alipore, Calcutta-27).

Use, Abuse and Toxicity of CANNABIS DRUGS

I.C. CHOPRA

Used widely all over the world in various forms, cannabis drugs are now known to produce highly toxic effects on the brain and lungs

THE use of cannabis drugs is widespread throughout the world. They are popularly known as *bhang*, *ganja* and *charas* in India; other common names are marihuana and hashish. These drugs are derived from the plant *Cannabis sativa* (Indian hemp), an annual occurring both in male and female forms. The Latin name "Cannabis" owes its origin to the Arabic *Kinnab*, which means, hemp. It is indigenous to Central Asia, but now grows wild in most temperate and tropical areas throughout the world. It has a long history of cultivation both as a source of hemp fibre and of psycho-active substances contained in its leaves and flowering tops. There are, however, substantial differences in the amount of psycho-active material in what may be different varieties of the plant. This material develops specially in the female plants particularly if they are not allowed to be fertilized. During cultivation this is effected by rooting out the male plants at the appropriate stage. In India, the plant grows wild in Assam, Bihar, Tamil Nadu, Uttar Pradesh, West Bengal, Jammu & Kashmir, Rajasthan and Kerala. The wild growth is less prevalent in the western and southern parts of India and is most luxuriant along the southern slopes of the Himalayas and the eastern border of Assam upto an altitude of 3000 meters (10,000 ft.) above sea level.

Cannabis is such an ancient economic plant, subjected over so many thousands of years by man to artificial hybridization and natural selection, that a vast array of cultivated varieties have appeared in different regions throughout the world. The stem yields long and strong fibres used for making canvas and ropes, the glands of the female flowers provide narcotic resin and the seed, an oil for paints and also for poultry feed.

Drugs that affect behaviour have been known since antiquity. As far back as 2700 B.C. cannabis was known to the Chinese Emperor, Shen Neng, and was used for a variety of medical purposes; in 500 B.C. the Scythians were reported by the Greek author Herodotus to be inhaling the vapours of burning hemp seed which gave them a feeling of joy and light-heartedness. In India, the earliest mention of *bhang* occurs in *Atharva Veda* (circa 2000 B.C.) which reported the therapeutic utilization of cannabis resin for its narcotic properties. *Ganja*, in Sanskrit, means 'light-hearted'. It has recently been estimated that because of its easy availability and low cost, there may be as many as 100 million casual or regular users of cannabis throughout the world. Chopra and Chopra (1957) estimated that India alone had more than 3 million habituees. The largest number were in Uttar Pradesh, followed by the Punjab, Haryana.

Dr. Chopra is emeritus scientist at V.P. Chest Institute, University of Delhi

Himachal Pradesh, Tamil Nadu, Bengal, Bihar and Maharashtra in the descending order of incidence and involving 0.5 to 1.0 per cent of the population. In the U.S. a massive programme on all aspects of cannabis abuse has been launched under the auspices of the National Institute for Mental Health, and parallel studies are being undertaken in other countries.

Chemistry of cannabinoids

The active principles of *Cannabis sativa* are contained in the resin produced by the female flowers. The five most important cannabinoids, as far as biological potency is concerned, are the tetrahydrocannabinols. They are,

1. (—)delta-9 *Trans*-tetrahydrocannabinol (delta-9 THC), also known as delta-1 THC ;
2. (—)delta-8 *Trans*-tetrahydrocannabinol (delta-8 THC), also known as delta-1(6) THC ;
3. delta - 9 *Trans* - tetrahydrocannabinolic acid (THC acid);
4. Cannabinol (CBN); and
5. Cannabidiol (CBD).

Delta-9 THC and delta-8 THC are psycho-active when taken orally or smoked. The THC acid is not active when taken orally but is partly converted into the active delta-9 THC or delta-8 THC isomers when smoked. CBN and CBD have very little psycho-activity but are present in fairly large amounts. CBD has significant antibacterial activity against a large variety of disease-producing bacteria which is at present under study.

Delta-9 THC produces most of the effects of cannabis in animals and men. At least 30 other cannabinoids have recently been isolated from cannabis, but relatively little information about their biological activity is currently available.

Deterioration on storage

Experience of excise authorities in the plains of India is that *Ganja* and *Charas* retain most of their potency for one year, after which they gradually begin to lose their potency and become quite unsalable and useless at the end of two years. *Bhang*, however, may retain its fairly good condition for 3-4 years. According to subjective symptoms of *bhang* users the drug, when freshly collected, is heat-producing and intoxicating. *Bhang* stored for 2 years or more is "mildly stimulating and pleasure giving". It is this particular type which is specially desired when joyful occasions are to be celebrated. *Bhang*, more than 3 years old, is used as a soothing and cooling drink during the hot season and is generally considered to be devoid of intoxicating properties. *Charas* deteriorates rapidly when exposed to heat and moisture.

Fig. 1. The cannabis plant

Delta-9 THC or delta-8 THC volatilize rapidly when smoked and are rapidly absorbed in the human lungs. The longer the smoke is retained in the lungs, the more potent are the effects.

The psycho-active THCs exist in many isomeric forms of which the delta-9 and delta-8 isomers are most active. The delta-3 isomer is less active and delta-5 isomer completely inactive. Many other analogues are now being synthesised and studied for biological activity.

Cannabis is a versatile drug with a wide range of activity. Besides its hallucinogenic action, it resembles cocaine and amphetamines in its euphoric and sympathatomimetic activity, and morphine in its euphoric and analgesic activity.

Dosage

In an extensive study of 1238 cannabis addicts in India, Chopra and Chopra (1939) observed that of these 62% were accustomed to drinking the milder *bhang* preparations. 446 (or 38%) however smoked the more potent *ganja* and *charas* preparations.

While the majority of *bhang* users kept to doses ranging from 1.5 to 3 gm daily, most of the *ganja* and *charas* smokers used 3-6 gm or more per day. These are heavy doses by standards of present Western usage and it is perhaps on this account that a mistaken impression of low toxicity of cannabis has been propagated in the Western countries.

It would appear that those who confine their cannabis use to *bhang* alone, seldom go to the excesses of *ganja* and *charas* smokers.

Bhang is used by the poor and well-to-do alike in many states of India as a mild narcotic and food accessory, whereas *ganja* and *charas* are used mainly for their euphoric and aphrodisiac effects, and less frequently for procuring a state of intoxication, under the influence of which daring acts may be committed. It is interesting to recall that it used to be a common practice amongst Rajput warriors to take some cannabis before going to battle, presumably to boost their courage.

Although there may be experimentation in teenagers, chronic addiction is rare. Heaviest use is in the age group of 20-40 years, after which its incidence diminishes rapidly.

Usually these drugs are taken only once a day, generally towards the evening when the individual feels tired after the day's work. However, *ganja* and *charas*, which are smoked and produce a more intense and short duration action,

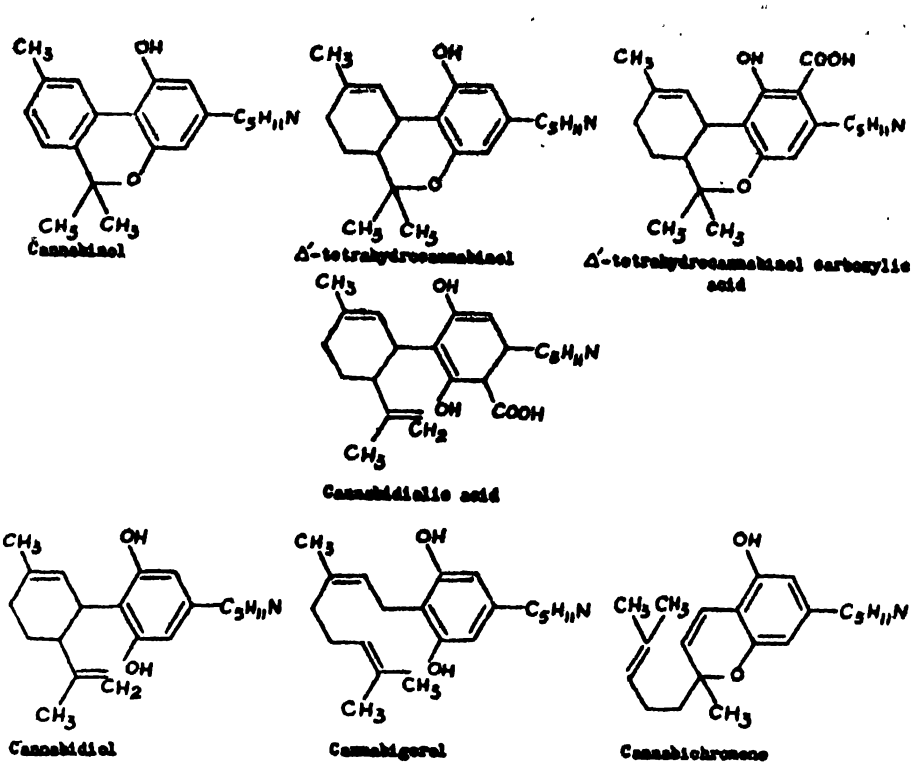


Fig. 2. Some active principles of cannabis drugs

are likely to be taken more often.

Delta-9 THC is three times more potent when smoked than when ingested. Smoking is therefore markedly preferred because the desired pleasant psychological effect is produced almost immediately. A quick and well defined feedback is obtained so that the user can titrate his intake to achieve and maintain the desired level of euphoria. Absorption of the drug from the gastro-intestinal tract is on the other hand slow and irregular, and the resultant effects variable.

Small doses produce a mild euphoria, whereas high doses generally produce marked distortion of sensory perception, depersonalization and derealization, and optical and auditory hallucinations.

Motivations for cannabis use

Perhaps the most important motivation for cannabis use (as also use of alcohol) is to facilitate social interaction. Cannabis, like alcohol, is used to produce a mild euphoria and some degree of emotional disinhibition. In a large series of habituees examined by Chopra and Chopra (1957) as many as 25 per cent stated that they had been persuaded by friends, acquaintances and relatives to indulge in the drugs, by ascribing all sorts of wonderful properties to them. Recent studies in Western countries confirm that personal curiosity and peer example are by far the most compelling reasons for initial use.

Another motivation for cannabis use, undoubtedly, is for enhancement of sensual pleasure. Cannabis has the reputation of enhancing the pleasure obtained from listening to music, appreciation of beautiful scenery or art forms. It increases the appetite and adds to the enjoyment of food, and increases pleasure derived from sexual activity. The Chopras in 1939 reported that 16 per cent of the over 1200 habituees they had examined had stated that they used the drug for euphoria and pleasure and over 10 per cent for enhancement of sexual activity.

Both in India and in other countries, cannabis drugs are widely used to have mystical experiences and self-understanding. The widespread use of *bhang* and *ganja* on religious occasions, and the very common use of *charas* smoking by *sadhus* and *fakirs* to help communication with the divine spirit, are only too well-known. However, drugs which modify mood and perception may be used as a part of a purely exploratory activity without any religious overtones. It is one of the many methods of attempting to diversify one's range of intellectual and aesthetic experiences and knowledge. This type of use is particularly characteristic of modern adolescents. Many users claim that hallucinogenic drugs increase artistic activity. Studies, however, suggest that it is only the subjective satisfaction of the artist rather than the artistic value of his creation, as assessed by others, which is enhanced.

Particularly in the Orient, self medication and quasi-medical use represent one of the most widespread motivations for cannabis use. A variety of cannabis preparations have popularly been used as household remedies for thousands of years in India for the treatment of many minor ailments, as a prophylactic against diseases, to sharpen the appetite, and to stimulate sexual activity. Clinical trials carried out by physicians on Indian patients in the last century showed cannabis to be a "useful anodyne, hypnotic and antispasmodic, next only in value to opium." Cannabis euphoria proved successful in some cases for combating mental depressive conditions and in the treatment of epilepsy. Other common quasi-medical uses were to relieve severe muscle pains and joint pains. They are also largely used for their soothing effects by those exposed to severe physical and mental strain. It was widely used in treating infections of the urinary tract.

Several cases of accidental deaths occurring in children who had smoked hashish from a waterpipe have been reported from Egypt. Such severe cases are more frequent in developing countries where nutrition and health facilities are meagre. It is likely that many cases of coma or sudden death from cannabis intoxication go unrecorded due to lack of adequate hospital facilities.

Subacute toxicity

Experiments with rats and monkeys who were given comparatively large doses of the drugs for 3 months, showed that the subjects went through an initial period of generalised depression lasting 5-10 days. However, tolerance to these depressant effects soon developed with appearance of hyperactivity, increasing grooming, tremors and aggressiveness. When kept in cages, the animals inflicted severe mutilating wounds on each other. Clonic and tonic convulsions appeared after 3-4 weeks; after 3 months, the animals receiving the higher doses died. Though doses used far exceed the heaviest known human dose, these studies are of great interest because they do point to the cumulative neurotoxicity of the psycho-active fractions of cannabis extracts, which may be related to the storage of cannabinoids in the fat deposits of the body from where they are slowly eliminated. It may be that high concentrations could be built over prolonged periods of cannabis consumption.

The major toxic effects of the cannabis drugs are on brain and lungs. With existing techniques, it is not yet possible to demonstrate gross damage to the central nervous system (CNS) by psychotropic drugs. These drugs exert their action through biochemical mechanisms which do not distort gross cell pathology. Thus even after 50 years of study of opiate toxicity in men and animals, it has still not been possible to establish any significant CNS damage after chronic administration of opium or morphine-like drugs. Neurochemists and neurophysiologists now believe that functional changes are accompanied by biochemical changes such as turnover of the brain hormones which regulate our thought processes. Frequent impairment of thought process by chronic cannabis intoxication, particularly during adolescent years, may well induce permanent changes in behavioural patterns.

The immediate effect of moderate diseases in habitual smokers is believed to be an initial feeling of anxiety and restlessness, followed by a refreshing and stimulating feeling. The sense of fatigue is alleviated and pleasurable emotions are experienced so that the drug addict is happy and finds everybody congenial. Restlessness ceases, tranquillity prevails as all worries are forgotten. Hallucinations of sight and hearing may occur and the senses become hyperacute and more subtle. However, some individuals are differently affected. They lose all sense of proportion and become irresponsible and may even commit criminal acts. Deep sleep generally follows an hour or more after indulgence in these drugs. The incidence of gross injuries to the brain such as insanity and moral depravity appears more frequently with *ganja* and *charas*.

Brain atrophy is a major nonspecific organic alteration which must obviously be preceded by other more subtle disturbances at the cellular and molecular levels.

Recent studies on cannabis drugs with radioactive labels showed that within 15 minutes the frontal cortex (the site of the functions or mentation) contained elevated concentrations of delta-9 THC. Another similarity between delta-9 THC and alcohol is their marked accumulation in the cerebellum which may be related to the motor uncoordination produced by both substances. 15 minutes after delta-9 THC administration, those parts of the brain which have connections with the visual pathways had high concentration of the drug. Accumulation of THCs and their metabolites in the amygdala may be related to the euphoric and anxiety diminishing effects in man.

The extremely high concentrations of delta-9 THC found in the frontal cortex, alongwith the hippocampal accumulation, is suggestive of the important part played by these structures in the distortion of time perception effect of cannabis. Studies in men have corroborated the metabolic pattern observed in animals. The prolonged lingering of cannabis metabolites for 4-8 days after administration is attributed to the fat solubility and plasma protein binding of these compounds, and to their recycling through the liver and small intesine.

The traditional use of cannabis for thousands of years in India in treating infections of the urinary tract may have a scientific basis, because of the diuretic activity combined with its known antispasmodic, pain-relieving and antibacterial activities. The temperature reducing effect of cannabis has been known for ages, and has now been confirmed in experimental animals and in man. This activity is of considerable therapeutic importance.

Damage to the respiratory system

There is a belief in many parts of the country that smoking of *ganja* and *charas* wards off attacks of asthma and bronchitis. On the contrary, excessive indulgence brings about these very conditions.

Reports by Chopra and Chopra (1939) and (1957) in India and by others from Egypt and the Middle East where potent cannabis preparations are smoked indicate that chronic catarrhal laryngitis, chronic bronchitis, emphysema and asthma are commonly found in heavy users. The high rate of pulmonary tuberculosis amongst all cannabis addicts examined might have been due partly to the poor economic conditions under which they generally live and partly due to the direct communication of infection from person to person as the common pipe is passed around.

Vascular damage

Chopra and Chopra (1957) reported that after a smoke of *ganja* or *charas*, the blood pressure rises slowly to the extent of 20-30 mm Hg. In the inexperienced, a few puffs on the *ganja* or *charas* pipe may produce a sharp rise of blood pressure followed by a rapid fall with the onset of symptoms of intoxication. Symptoms of collapse may be produced, the blood pressure remaining low for a considerable time. It has recently been suggested that cannabis drugs might find a place in the treatment of hypertension. A high incidence of chronic digestive disturbances has been observed in a large proportion of chronic heavy users—especially of *ganja* and *charas*.

Teratogenicity

This term implies toxic effects resulting in deformities in the offspring, as in the case of the notorious Thalidomide disasters. Experimental evidence is not conclusive. However, injections of cannabis resin to pregnant rats from 1-6 days of gestation led to significant evidence of congenital malformations in the offspring. Similar observations have been made in foetal hamsters and rabbits.

Interaction with other drugs

As cannabis addicts frequently resort to multiple drug use, it is of interest to study the interaction of the cannabinoids with others drugs. Chopra and Chopra (1957) reported that in India cannabis drugs are sometime fortified with other active ingredients such as tobacco, alcohol, *dhatura*, opium and seeds of nux-vomica (which contain strychnine). Less frequently, the juice of *ak* (*Calotropis gigantea*), bamboo shoots arsenic and strychnine itself are added. In parts of Baluchistan, a drink called *madra* containing *dhatura*, opium, *bhang* and alcohol used to be a popular intoxicant.

In experimental animals, delta-9 THC has been shown to potentiate the cardiovascular action of epinephrine with amphetamines and caffeine in stimulating locomotor activity.

Summary

Cannabinoids are not the innocuous low-toxicity drugs as has been suggested by the recent Wooton Committee report in the U.K. and a U.S. Govt. report on Marihuana in the U.S.A. THC has a very high fat solubility and binds to plasma and cellular proteins. It is recycled through the liver-small intestine system and is thus capable of cumulative toxicity, as metabolites accumulate in the brain and other tissues and are slowly eliminated over a number of drugs in the urine and faeces. It induces enzymes in the lungs and liver which in turn produce the psychoactive 11-hydroxy THC metabolites. Contrary to the popular belief that cannabis drugs are not addicting, delta-9 THC rapidly induces tolerance in all animal species studied. Its primary effects are on Central Nervous System where it alters the turnover rate of the major neuro-transmitters, 5-hydroxytryptamine and acetyl choline. It interacts with other commonly used centrally acting drugs particularly alcohol, amphetamines and the barbiturates.

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JAI SINGH II

And Contemporary Indian Astronomy

A. RAHMAN

INDIA, as we know, had in the past considerable achievements to her credit in the field of science and technology. Some of the recent researches have shown that as late as the 17th century, scientific knowledge in the fields of biology, medicine, engineering and certain technologies was quite extensive as compared to Europe. In the fields of astronomy and mathematics European scientists had made a breakthrough during this period leading to rapid development in these sciences. However, even in these fields the degree of attainment of knowledge in India was of a high order, though it had reached a point, due to several factors, where it was to stagnate. These developments were soon to leave India far behind reducing it to the level of a backward country.

India had a rich and long tradition in astronomy. Among the noted workers in the field was Raja Sawai Jai Singh II (1686-1743) of Jaipur. His interests and contributions to astronomy are fairly well documented. His personality as well as endeavours throw considerable light on the nature of science in India and also on the reasons for its inability to evolve further.

Jai Singh has always evoked admiration of Indian scientists and nationalists. He is often quoted, as an example, if not a model, of the spirit of scientific enquiry in India. His endeavours in the reform of calendar, instruments of astronomical observation, and the establishment of observatories are taken as a continuation of the pure Indian tradition or a revival of the tradition whenever circumstances became favourable. Jawaharlal Nehru, for instance, mentions Jai Singh in the following words:

"Jai Singh would have been a remarkable man anywhere and at any time. The fact that he rose and functioned as a scientist in the typically feudal milieu of Rajputana and during the darkest period of Indian history, when disruption and war and tumults filled the scene, is very significant. It shows the spirit of scientific enquiry was not dead in India and there was some ferment at work which yielded rich results if only an opportunity had been given to it to fructify. Jai Singh was no anachronism or a solitary thinker in an unfriendly and uncomprehending environment. He was the product of his age and collected a number of scientific workers with him. Out of them he sent some to Portugal; social custom and taboo did not deter him from

The total neglect of the contemporary development in astronomy by Jai Singh II, especially in the areas of concepts, obeservation and instruments is strikingly significant

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Interior view of the *Ram-Yantra* (Jantar Mantar, Delhi)

doing so. It seems probable that there was plenty of good material for scientific work in the country, both theoretical and technical, only it was to be given a chance to function. That opportunity did not come for a long time.."

Nehru's comment on Jai Singh has many dimensions. More than assessing his contributions to astronomy, Nehru, probably, was reacting against the revivalist trend which had often asserted that the Indian intellectual tradition was primarily in the domain of spirituality and religious thought. In highlighting the endeavours of Jai Singh, in my opinion, he took the opportunity of asserting the scientific dimensions of our culture and tradition.

Choice of the problem, techniques and method

Let us briefly look at the astronomical researches of Jai Singh and try to throw some light on why he was interested in this subject, the reasons of his choice of the problem, the methods he followed to solve it, and finally assess the results of his efforts.

The main reason for Jai Singh being involved in astronomy was his devotion to the study of mathematical science and the bent of his mind which "was constantly directed to the solution of the most difficult problems."

The main problem which he aimed to solve was the recurrent problem of the reform of calendar, arising out of the difference between the position of stars and planets as calculated from the astronomical tables and as observed. This difference was due to lack of appreciation of the different types of motion. The shift in position of stars and planets was due to different types of motion. The daily and annual motions and their effects, however, were fairly understood. We now know that besides these there are a number of other motions such as the precession which affect the position of stars and planets as observed from the earth. Since the medieval systems did not take into account such changes, the difference between the calculated and observed positions of stars would creep in a few decades and need corrections. It was solved through better understanding of different types of motions, their impact on the observed position of stars and planets and a better conceptual framework of the solar system, first developed by Copernicus and further refined by Kepler, Galileo and Newton. Jai Singh, however, considered the problem of shift in position of stars and planets due to precession as merely a problem of inaccuracy of earlier observations.

The need for predicting the appearance of the new moons, or an accurate calendar, was felt primarily because of the necessity of fixing the dates of religious festivals and for general administration. Having received the command of the King and conscious of the difficulties of the task, Jai Singh decided to proceed in four stages:

(i) collection of the latest information about recent developments in astronomy;

(ii) construction of new instruments of observation;

(iii) building a number of observatories; and

(iv) preparation of the astronomical tables.

To collect the latest information he sent emissaries to distant lands and also invited to his court a number of astronomers from European countries.

In the pursuit of his objectives to reform the calendar and recognising the crucial importance of observation, Jai Singh concentrated on developing what he considered to be new and better instruments of observation and building a number of observatories in different centres. The brass instruments used at that time did not come up to the idea which he had formed of the accuracy because of the smallness of their size, lack of division into minutes, wearing of axes, displacement of the centres of the circles, and the shifting of the planes of the instruments.

The "instruments" of observation which he developed were many and were mostly large-sized masonry structures. The reasons he gave for this and the methods he followed in constructing them are interesting. He constructed in Darul-Khilafah Shah Jehanabad (present Delhi) which was the seat of the empire and prosperity, instruments of his own invention, such as *Jai-Prakash*, *Ram-Yantra* and *Samrat-Yantra*, the semi-diameter of which was eighteen cubits, one minute on it being the size of a barely corn and a half. The structures made of stone and lime were of perfect stability.

Jai Singh also built a number of observatories mainly with a view to removing the differences which had existed between the computed and observed places of the fixed stars and planets. In order to confirm the truth of these observations he constructed the instruments of the same kind at Sawai Jaipur, Benaras and Ujjain. When he compared the observations, after allowing for the differences in longitude between the places where they stood, they agreed with calculations.

Jai Singh's interest in astronomy was not merely theoretical. It was motivated by a strong desire to set up efficient modern observatories for improving upon the observational data and producing accurate astronomical tables. Unfortunately, however, the good start made by Jai Singh and the excellent work done by the people he gathered around him came to an abrupt end at his untimely death in 1743.

Contemporary European astronomy

Copernicus' book *De Revolutionobis* was published in 1543. The ideas contained in the book were further developed by Kepler (1571-1630), Galileo (1564-1642) and finally modified by Newton (1642-1727). Further, the telescope as a major instrument of astronomical observation was developed and used by Galileo in 1609 or there about. Its use soon became extensive making it a major instrument of astronomy. The total neglect of the contemporary development in astronomy by Jai Singh especially in the areas of concepts, observation, and instruments of observation is strikingly significant.

It is difficult to believe that Jai Singh had not come across the names of Copernicus, Kepler, Galileo and Newton or was not exposed to their works and ideas. Similarly, it is difficult to believe that he would not have heard of the telescope. It is indeed puzzling that in his beautifully and eloquently written introduction to *Zij-i-Jadid Muhammad Shahi*, he neither mentions the founders of modern astronomy nor the telescope. In his own work, instead of using the telescope, he continued to use the medieval instruments by only modifying them slightly, converting them in masonry and increasing their size.

We are also at a loss to understand that despite the fact that he was well-versed both in astronomical theory and observational methods and techniques, he limited his objective to a rather superficial task of correcting the calendar rather than taking upon himself the task of changing the conceptual framework of astronomy. The latter would have enabled astronomers to predict more accurately positions of the stars and planets and organise calendar in a manner which would not need frequent revisions. If he could not have done it himself he could have at least adopted the Copernican system, which was by then fully developed and accepted by most of the astronomers.

One plausible reason for his not getting the information about Copernican revolution could be the fact that his contacts with Europe were mostly through religious missionaries of the catholic church who may have been opposed to the Copernican system. Two facts, however, go against this supposition. It is known that he had obtained a copy of Flemstead's *Historia Geolestic Britannica*, and de la Hire's *Tabulae Astronomicae*. Though he does not mention the former, the latter is mentioned in the introduction to *Zij-i-Jadid Muhammad Shahi*. Besides, if he had discussed the developments of astronomy in Europe with the jesuit missionaries "it is entirely possible", as mentioned by Blanpied, "that one or more of them would have mentioned the dispute over Copernican theory if only to convince the Raja of the error of the theory." Blanpied goes on to suggest that Jai Singh was not interested in dynamics of planetary motion at all. "His professed aim was to perfect the catalogue of stars and planets, a task that does not require an examination of the basis of their motion."

The *Samrat Yantra* with the *Misra Yantra* in the background (Jantar Mantar, Delhi)

This suggestion of Blanpied does not appear to be correct and acceptable.

A conclusion which one could draw from his ignoring the telescope completely is that even though he might have found the instrument novel, he may not have found it of much efficacy. Secondly, he might have been so convinced of the rationality, efficiency, correctness and originality of his own instruments that he dismissed it as of no consequence.

It is also possible that Jai Singh could not appreciate fully the problem of the reform of the calendar in all its wider dimensions. The precession was not known to him and he could not appreciate, as mentioned earlier, shift in the position of stars and planets arising out of it. Since he had reformed the calendar, he may have convinced himself as having solved the problem for all times. Taking such a view might have led Derek Solla Price to suggest:

"History seems to play cruel jests with the most heroic efforts of astronomers. Tycho Brahe, author of most precise and painstaking observations in naked eye astronomy, supported by a lifetime of work and kings ransom of instrumentation, died just before the invention of the telescope was to make all his labour in vain. More than a century later, just as scientific contacts between India and Europe had been established, Jai Singh repeated the tragedy of Brahe, aware, but in corresponding which the functional architecture and big expenditure of the Jaipur observatory were to be regarded as a common place of civilization."

Discussion of the problem and conclusion

One would be tempted to agree with Blanpied that Jai Singh limited his task to one of reforming the calendar, to which the question of the conceptual framework was irrelevant, or be charitable like Derek Price and say that history played a cruel joke on Jai Singh, but for the fact that the lack of mention of the heliocentric system and its builders and the telescope appears, from the available evidence, as deliberate.

The reason to us appears to be in the social climate of the period in which Jai Singh lived, in which new ideas and new conceptual framework could hardly emerge. This would be evident if we were to compare the developments in India with those in Europe. We find in Europe the emergence of new ideas, intellectual movements and new philosophies appearing simultaneously with the growth and development of new productive forces and relationship, if not preceding the former.

As against these we do not have any record of such developmets in India. Feudalism, even though getting exhausted and breaking up, was still dominant at the time of Jai Singh. The King in Delhi—the

Mughal Emperor—though weak and often powerless was still the centre of empire and focus of attention. Jai Singh owed allegiance to the Mughal Emperor at Delhi till the end of his life. He fought wars, carried out diplomatic negotiations and other missions on his behalf. Under these conditions and circumstances he could hardly be expected to carry out a major reform, to sweep the old system of astronomy—the geocentric—and to replace it with the new—heliocentric. Like his political objective to maintain and extend the feudal empire, his objective in astronomy was within the framework of the then existing long established tradition of Ptolemy—through Ulugh Beg—to his own.

The decision to ignore the contemporary developments in astronomy might have also been dictated by the wider implications of the system. The link-up of feudal mode of thinking and religious ideas was complete, the two supported each other and the geocentric system was part of the religious mode of thinking. Consequently, to overthrow the geocentric system was to destroy the base of religious control over the people. The religious festivals, dates of marriages, horoscopes and ceremonies were all calculated through this system of astronomy and to discard it completely would have led to destroying a system which was cultivated and refined over centuries and designed to control and regulate the life of people.

Seen in this light, Jai Singh even though was brilliant with a questioning mind, systematic, methodical and painstaking in approach and in a way creative and original with remarkable many-sided personality as a soldier, statesman, scientist and town planner and architect remained a prisoner to the then existing framework of ideas and concepts and with all his labours and expenses did not enrich astronomy. What he has left to us is more in line with the medieval tradition of architecture in India—a tomb, a tomb of medieval astronomy to carry down his name and fame to generations to come, no doubt, but it was not a point of take off for the future. It is like the Taj Mahal, beautiful to look at, even evoking a feeling of wonder, at the ingenuity, but built to mourn the dead, not to herald the birth of new.

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TOWARDS STRONGER GLASSES

HEM SHANKER RAY

Glass can be made stronger if the surface layer, which develops flaws such as micro-cracks, is removed or altered to hinder propagation of cracks

A UNIQUE combination of useful properties has made glass a versatile and useful material throughout the ages. It is transparent, durable, non-deformable and cheap. It is cast or blown easily. And it exhibits excellent corrosion resistance against a very wide range of chemicals. However, use of glass has been traditionally limited severely due to its vulnerability to breakage because of poor strength. If glass could be made stronger then the range of its applications would widen considerably.

When glass is subjected, for short periods, to stresses within certain limits, there is strain proportional to stress. The strain disappears and the piece returns to its original dimension after the removal of the stress. This is the common elastic behavior. With many substances, notably metals, on addition of load beyond the elastic limit, a plastic condition is reached in which yielding takes place continuously and, if the load is maintained, ultimately fracture results. Elastic and plastic deformations may be indicated using stress-strain diagrams as shown in Fig. 1.

For glass, there appears to be no region of plasticity and Hooke's proportionality law holds upto the breaking point. It is a perfectly brittle solid with no plasticity i.e., it cannot be deformed permanently.

Glass may be broken in many different ways—by tension or compression, twisting or impact. Apparently, there is no connection among the different strength values. It is, however, very probable that in all these various modes of applying stresses, a fracture always takes place in tension. That is, the fracture results from tensile stresses generated by the real applied load. A failure under uniform compression is unthinkable

Surface cracks reduce strength

The theoretical strength of a material is estimated on the assumption that it contains no imperfections and that the failure occurs when the bonds between individual atoms are broken. Using this approach and considering glass as perfectly brittle solid, the theoretical strength of glass is calculated to be around 1000 kg/cm^2. In practice, however, the tensile strength for ordinary glasses is 5 to 15 kg/mm^2 only. This descripancy implies that the mechanism by which ordinary glass fails is something different from breaking of bonds.

The popularly accepted theory regarding mechanism of failure was first postulated by a scientist named A.A. Griffth more than fifty years ago. The theory postulates that there are many surface flaws in the form of micro-cracks and there are high stress concentrations at the tips of these cracks. Because of the prevailing stress concentrations, the cracks propagate under low stresses causing the material to ultimately fail.

Dr. Ray teaches metallurgical engineering at Indian Institute of Technology, Kanpur

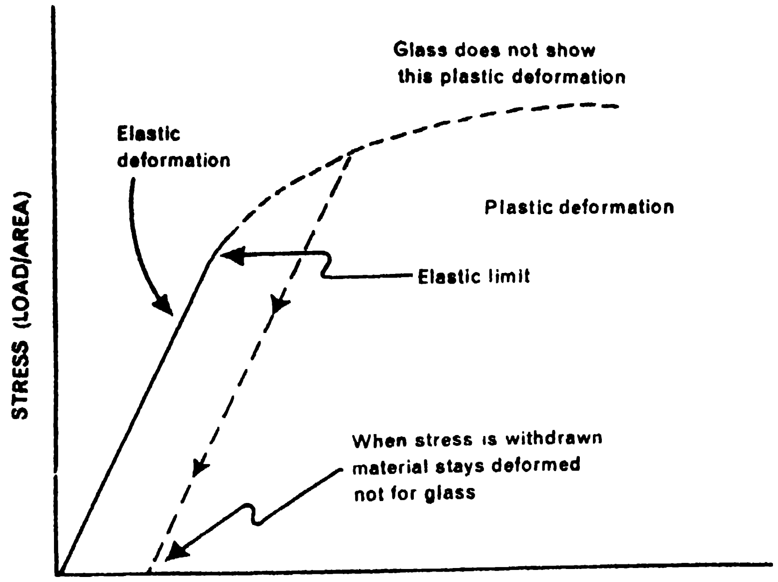

Fig. 1. Stress-strain diagram to show elastic and plastic deformations

Although the Griffith cracks are usually too small to be visible to the naked eye or even under a microscope, numerous indirect observations have substantiated the theory. It has been observed that fine glass fibres freshly drawn from glass melt have strength approaching the theoretical values. However, if these fibres come in contact with solid objects, or even if they are allowed to stand in atmosphere for sometime then the strength is greatly lowered. This observation suggests that the strength of glass depends on surface conditions.

Griffith cracks, which are usually of dimensions around 500 Å are said to be elliptical. The direction of crack propagation is along the larger width. Fig. 2 shows the picture of an elliptical crack and indicates how a crack would propagate under a tensile stress *across* the length of the crack. It is only the flaws that stand across the direction of stress that are of any importance. The larger the surface area of glass the greater is the probability that a flaw of critical size exists. Articles with larger surface areas are, therefore more liable to fail. Obviously, the methods to strengthen glass must aim at either removing the surface flaws or changing the surface conditions so as to make crack propagation difficult.

Methods to strengthen glass

Attempts to strengthen glass objects have been made at least as early as the seventeenth century. In the most classical method glass is subjected to controlled quenching so as to introduce high surface compression together with balancing tension in the interior. Such a glass would be stronger so long as the exterior is not pierced. It is, however, difficult to control the process and generate uniform stresses all around. Consequently spontaneous breakage is not uncommon. In another classical approach, a low-expansion-coefficient glass is laid over a high-expansion-coefficient glass at high temperatures.

After cooling the greater contraction of the core compared with the surface layer puts the surface under compression and core in tension. These procedures are occasionally still used today under controlled conditions. It should be obvious that one may also improve strength through removing the surface layer by very careful polishing. This, of course, is a very difficult procedure.

All modern strengthening processes either eliminate the surface flaws by removing a surface layer or prevent the flaws from propagation by changing the patterns of stress concentrations. In general we can categorize these methods as either physical or chemical. Physical methods do not change chemical composition of the surface while chemical methods do. Here we will briefly discuss all processes with slight emphasis on the latter.

Acid polishing or chemical etching. Strength may be enhanced by removing the defective surface layer of glass through etching with an aqueous acid solution or with suitable molten salt mixtures. Removal of a thin surface layer automatically eliminates surface flaws. Acid-etched glasses, however, loose strength rapidly when heated over 200°C. Strength may drop ten-fold or more. The phenomenon is still

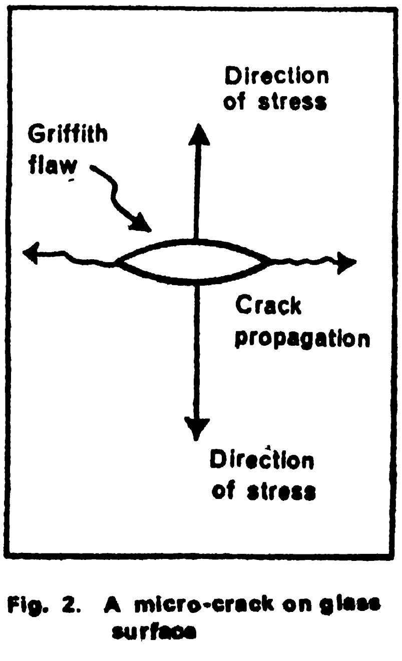

Fig. 2. A micro-crack on glass surface

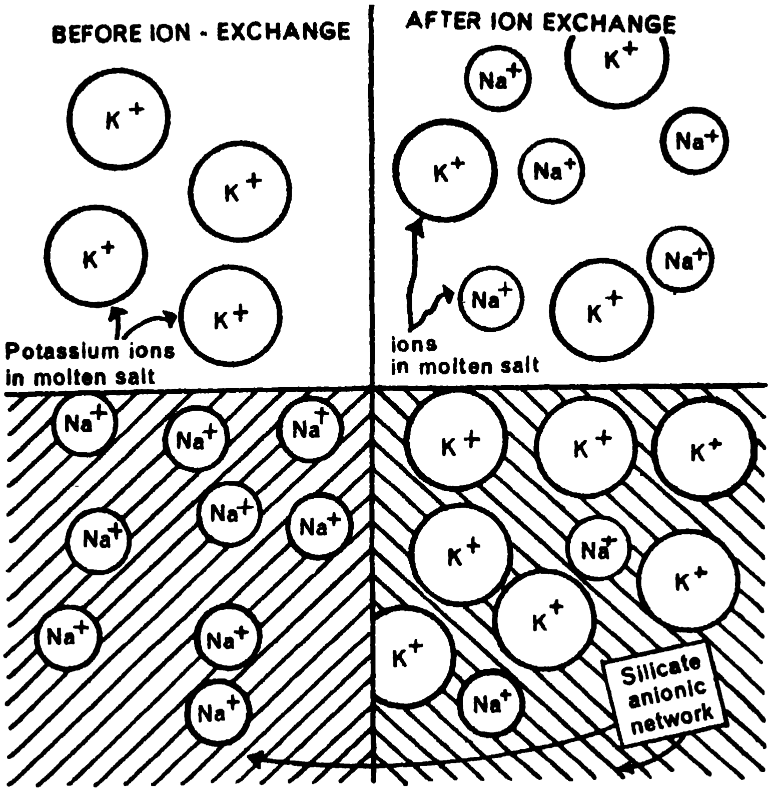

Fig. 3. The ion exchange reaction

not understood clearly but it might be attributed to possible changes in the state of hydration of glass surface during heating. Hydration is caused by the aqueous medium.

One may propose, in the light of the preceding observation, that anhydrous etchants would be better. This has been found to be true. Molten salts dissolve many inorganic oxides, fluorides, fluorophosphates and borofluorides which may be used in etching. For example, solution of sodium or potassium borofluorides in alkali nitrates etches glass at a good rate. This increases the strength. High strengths thus obtained are not lowered by heating.

It should be obvious that etched glasses will retain strength only if the surface is kept covered by plastic lequer, etc., if left exposed, the surfaces would develop flaws again.

Tempering. Tempering is the classical process where compressive stresses are introduced on the surface through controlled quenching. As said earlier, cracks cannot propagate under compressive stresses. Tempered glasses, however, may not be good abrasion resistant.

Sand blasting. Sand blasting is an alternative procedure to check crack propagation. Here very fine sand particles are bombarded on the glass surface. This renders the notches of cracks blunt. Stress concentrations at the notches become low and crack propagation becomes difficult. For proper blasting the sand particles must be very fine, as coarse particles cannot blunt notches.

Chemical strengthening; Ion exchange

Cheminal strengthening process aims at changing the composition of the glass surface through some ion exchange reaction so as to introduce compressive stresses. Consider some common soda lime glasses which mainly contain Na_2O, CaO and SiO_2. The structure of such glasses is characterized by network of silicate ions with a uniform distribution of cations (Na^+, Ca^{2+}) There is an abundance of Na^+ions in the bulk and at the surface. If, through some method, a large number of sodium ions in the surface layers be substituted by potassium ions which are bigger, the resulting surface would be under compressive stresses. This may be achieved through an ion exchange reaction by immersing the glass in a molten potassium salt bath. The reaction is schematically shown in Fig. 3.

The ion exchange process cannot be applied to glasses in which prior strengthening by acid etching has taken place for the simple reason that exchange reactions need molten salts at elevated temperatures where acid-etched glass has poor strength. Glasses etched by molten salts can be further strengthened by ion exchange because of their thermal stability. In fact, fused salt etching and ion exchange may be combined by using a suitable bath.

Ion exchange reaction, however, has a serious drawback. The high compressive stresses are introduced only in a very thin surface layer (no more than, say, 30 microns). Therefore, the strength dissipates rapidly if there is any mechanical damage to the surface.

Slow nature of ion-exchange. The final strength of glass depends on various factors, e.g., size of foreign ion introduced and its number per unit area of surface. The latter would depend on time and temperature of reaction factors which control the diffusion phenomenon. The effect of time and temperature is schematically shown for an arbitrary glass specimen in Fig. 4. It shows that after 6-7 hours the rate of strengthening slows down too much to be of any use in commercial practice. Although increased temperature does help to some extent by accelerating the diffusion of foreign ion, this cannot

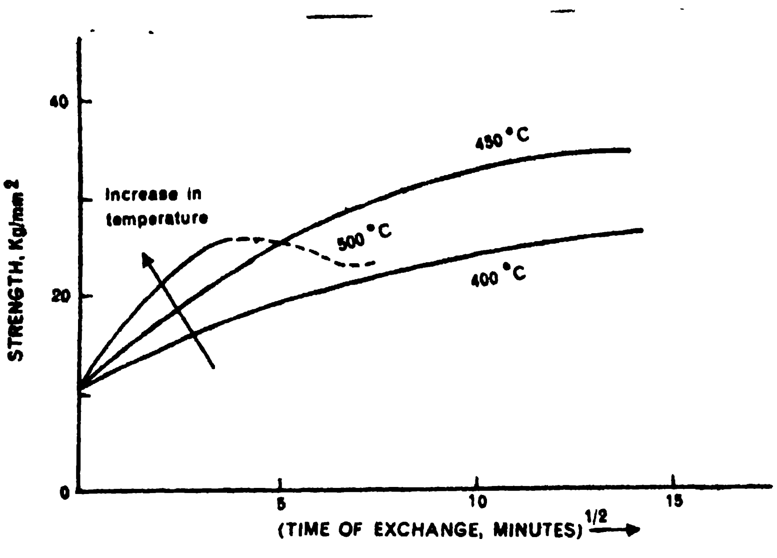

Fig. 4. Effect of time and temperature on strength during ion-exchange

help much. As a matter of fact sometimes there is a drop in strength if the temperature is too high, as is indicated by the dotted line.

Recently Tiwari has done a careful experiment to show exactly what happens when a glass surface containing sodium ions is immersed in a potassium nitrate bath (A.N. Tiwari, 'Some diffusion studies in sodium aluminoborate glasses', M. Tech. Thesis, I.I.T., Kanpur, 1970). After a given amount of ion exchange in the bath the glass was withdrawn, washed and the surface layers were analysed for residual sodium and added potassium ions as a function of depth. Interior layers at various depths were exposed gradually by etching off successive layers in 0.2% HF solution. The concentration profiles of sodium and potassium ions near the surface for a typical glass are shown in Fig. 5.

The experiment clearly demonstrated that near the surface almost all sodium ions were replaced and that the total concentration of Na^+ plus K^+ remained constant at any given depth. This experiment also substantiates the accepted fact that even after long hours the thickness of the ion-exchanged layer remains very limited. This is so because diffusion of ions in the solid is basically slow. Obviously, the thickness would perhaps be more limited if a molten salt mixture, e.g., potassium borofluoride and potassium nitrate, is used both for etching as well as ion-exchange. In this case a situation would be reached where the rate of diffusion would equal rate of etching giving rise to a steady thickness of the ion-exchanged layer.

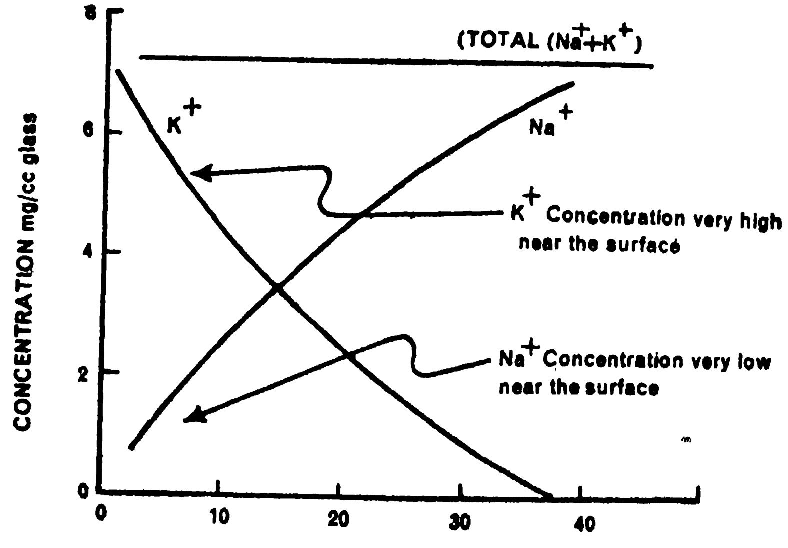

Fig. 5. Concentration profiles of sodium and potassium ions near the surface

Greater penetration in the glass may be obtained by using ions, such as silver, which diffuse faster. Rate of diffusion of silver ions into soda glass is nearly hundred times greater than that of potassium ions. Exchange involving silver ions therefore give much improved abrasion resistance.

Other methods. Several other methods of strengthening glass are also being investigated. In one method the surface layers are crystallized using suitable nucleating agents and heat treatment. There should be a layer of bulk glass sandwitched between two layers of crystallized material. The crystallized layer generates compressive stresses. The composition of the crystallized material should be such that its properties bear a certain relation to the properties of the bulk glass. For example, the thermal expansion coefficient of the crystallized material should be lower than that of glass.

In another approach attempts are being made to disperse some metallic phase at the surface. The metallic phase being plastic would absorb and dissipate stress concentrations at the notches and prevent

(*Continued on page 338*)

INORGANIC POISONS
And Their Antidotes

D. CHAKRABORTI

INORGANIC chemicals can create hazards. We often neglect the matter whereas immediate precautions should be taken, lest within a short span or in the long run they may cost us our lives. It is estimated that the number of deaths from chemical poisoning exceeds several millions a year in the world. The study by National Cancer Institute, U.S.A., has shown that the occurrence of certain forms of cancer is widespread among chemists. This may be due to poisonous effects of chemicals used. Antidotes are chemical compounds employed to nullify the toxicity of poisons. For each poison there is a specific antidote. Whenever the nature of a poison is unknown, universal antidote is used which is applicable to all kinds of poisons.

Several common inorganic chemicals can cause serious poisoning when ingested or even on contact with skin. Fortunately, for each poison specific antidote is available whose timely use can prevent the mishap

Human body contains and requires a large number of inorganic ions. Ca^{2+}, K^{+}, Na^{+}, PO$_4^{3-}$, and Cl^{-} are present in relatively large quantity in the body together with small amount of ions like Mg^{2+}, Fe^{3+}, Cu^{2+}, Co^{2+}, Mo^{6+}, Mn^{2+}, F^{-}, I^{-}, etc. These ions play an important role in nutrition. Without them life cannot sustain. But the very ions which play so vital a role can even cause hazards when taken in excess. For example, iron and copper are essential constituents of blood, a characteristic anemia develops when only milk is given as food to infants or growing children. It may be due to deficiency of iron and copper. But excess iron and copper intake may cause death. In the U.S.A. 1 to 2 children die every month from iron and copper poisoning. Again, transitional elements and magnesium activate enzymes (enzymes are proteins with active sites) which are involved in carbohydrate metabolism, lipid metabolism, etc. Also magnesium deficiency leads to irritability of nervous system, but excess of magnesium intake causes increased excretion of calcium in urine, which in turn causes respiratory defect and depression in blood pressure. There is also a belief that agin involves excess metal ions depositio in tissue (specially of copper). Som also believe that cancer in age people may be due to excessiv metal ion deposition.

It is clear that ions which are vita for human life may also caus hazards. Moreover, elements whic are not present in body can als cause serious poisoning when ingested or when they come in contac with blood or skin.

Beryllium poisoning

Beryllium poisoning causes a disease of the type pulmonary granuloma (pulmonary means lungs, granulue means nodule) which ma appear even six years after berylliu poisoning. Complete recovery fro

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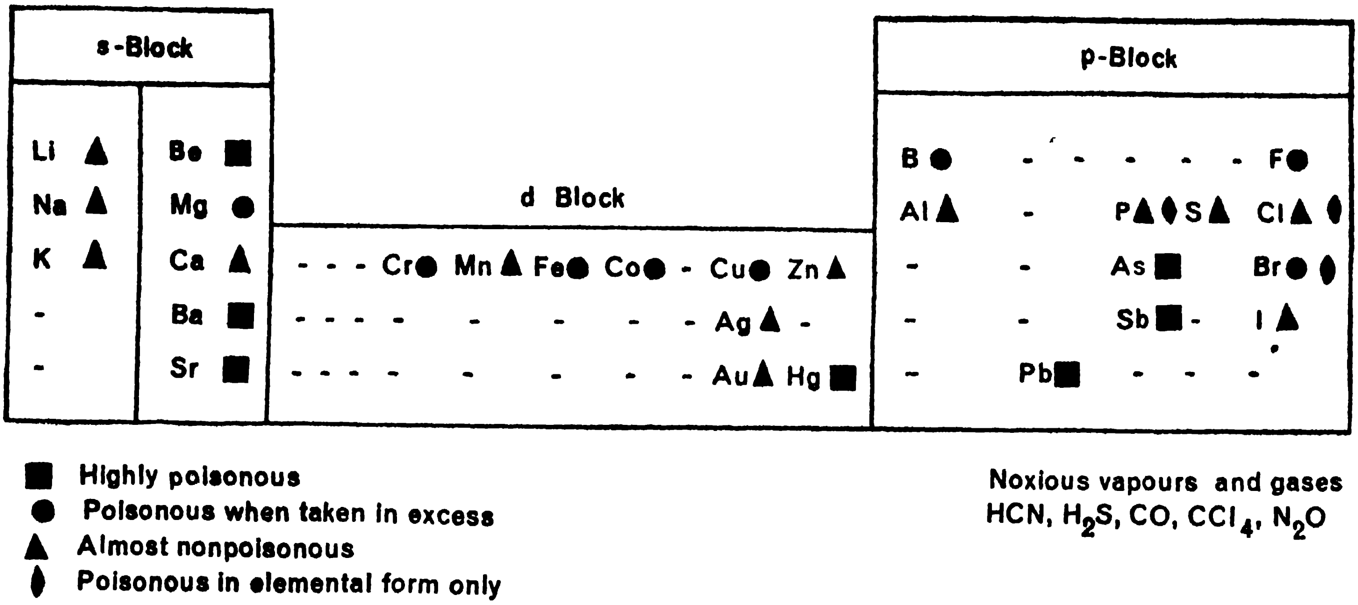


Fig. 1

this disease is uncertain. Even when a beryllium compound comes in contact with skin it may cause nonhealing type of ulceration.

The poisonous character of beryllium is due to interference with carbohydrate metabolising cycle, i.e., the cycle by which we obtain energy. Also beryllium prevents breakdown of phosphorylated compounds. It has been observed that beryllium concentration of 10^{-6} M inhibits alkaline phosphatase enzyme present in bile secretion.

The chemical compounds which possess the property of nullifying the toxicity of poisons are called antidotes. Antidote proposed for beryllium poisoning is aurin tricarboxylic acid. It inactivates beryllium by forming a nontoxic complex with beryllium. Certain trace elements are supposed to enhance bacterial and fungal growths. It is believed that the activity of some antibiotics depends upon their ability to form complex with these elements making them unavailable to the harmful bacteria, fungi, etc. Tetracycline is an example. A few antidotes are shown in Fig. 2

Complex formation with poisons is not the only way an antidote can act. An antidote can nullify the toxicity of poisons in some other ways also. It can remove the poisonous part from the body by (i) acting as laxative or emetic, (ii) forming a layer on poison so that it is not further absorbed by the body, and (iii) changing the toxic compound into another compound nonpoisonous to the body.

Cyanide poisoning

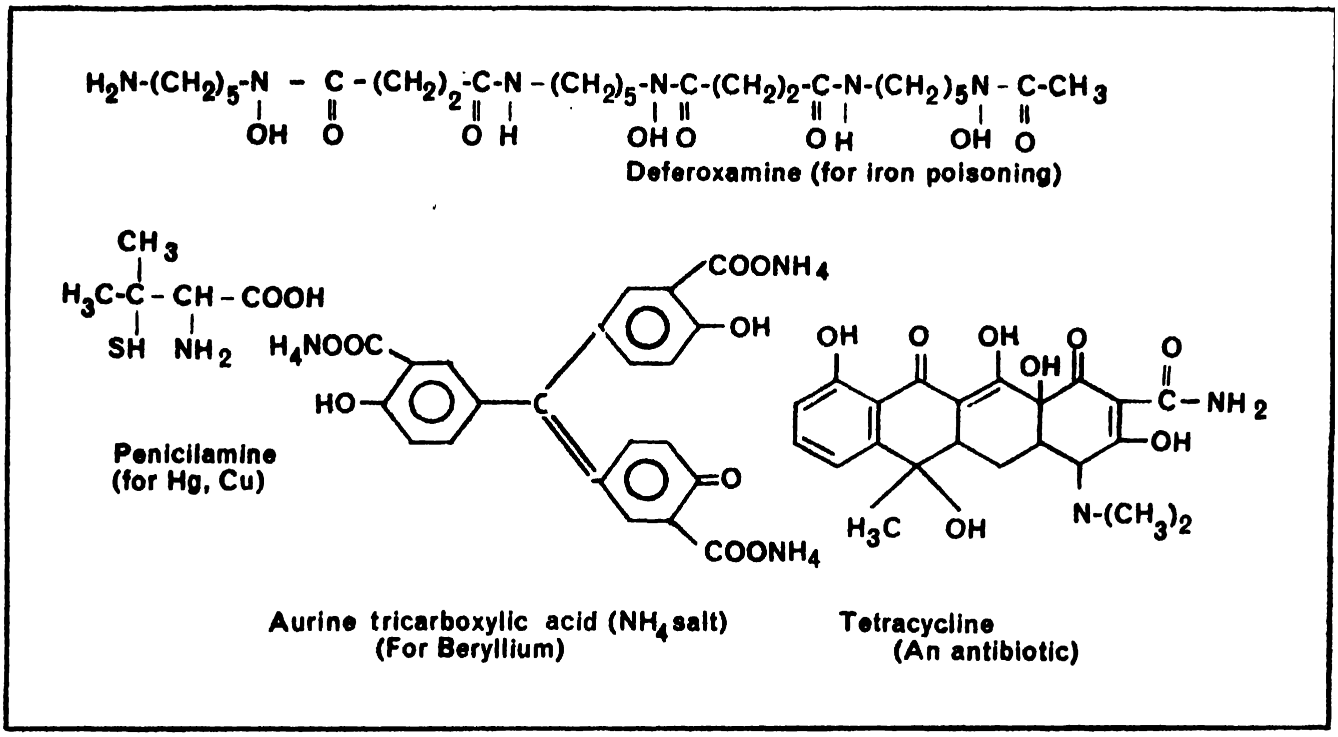
All soluble inorganic cyanides possess toxic property. Cyanide poisoning is solely due to cyanide ion. Symptoms of cyanide poisoning appear within few seconds to a minute after ingestion of a compound or inhalation of vapours containing cyanide ions. The symptoms include giddiness, headache, palpitation and unconsciousness. A high dose will kill a man within a few minutes (but not in a few seconds as generally believed). Cyanide poisoning can be diagnosed from the breath of the patient which has characteristic cyanide odour resembling bitter almonds.

All pharmacological actions of cyanide ions known as cytotoxic hypoxia result from their toxic effect at cellular level. Actually the toxic effect is due to the combination of cyanide ion with cytochrome oxidase enzyme forming cytochrome oxidase-cyanogen complex.

With the help of rhodanese enzyme of cellular mitochondria and endogenous supply of S_2O_3,$^{2-}$ major portion of cyanide is excreted, but it cannot be excreted totally due to limited endogenous supply of S_2O_3.$^{2-}$ The actual treatment for cyanide poisoning for an adult consists of, first, injecting (intramuscular) 0.3-0·5 gm of sodium nitrite dissoved in 10-15 ml of water. In cases of inevitable delay, patient is subjected to amyl nitrite inhalation for 30 seconds after each 2 minutes interval. Following sodium nitrite, sodium thiosulphate should be given intravenously. The dose is 12.5 gm in a total volume of 50 ml, of water, administered within a period of 10 minutes. If symptoms reappear, half of the dose should be repeated.

Hydrogen sulphide poisoning

Hydrogen sulphide is commonly used by chemistry students,


$H_2N\text{-}(CH_2)_5\text{-}N - C - (CH_2)_2\text{-}C\text{-}N - (CH_2)_5\text{-}N\text{-}C\text{-}(CH_2)_2\text{-}C\text{-}N\text{-}(CH_2)_5N - C\text{-}CH_3$
OH O O H OH O O H OH O
H_4NOOC
HO
C
$COONH_4$
OH
O
$COONH_4$
OH O OH O OH O
$C - NH_2$
OH
H_3C OH
$N\text{-}(CH_3)_2$

Deferoxamine (for iron poisoning)

Penicilamine (for Hg, Cu)

Aurine tricarboxylic acid (NH_4 salt) (For Beryllium)

Tetracycline (An antibiotic)

Fig. 2

specially those who are in schools and colleges. Hydrogen sulphide is more poisonous than cyanide. It is an insidious poison. Its familiar rotton-egg smell is characteristic even at extremely low concentrations. At higher concentrations a progressive paralysis of olfactory nerves occurs and its odour can no longer be detected. Instead, a sweetish taste is noted. Concentration of 600 p.p.m. is fatal in 30 minutes, while undiluted gas is quite fatal. Death results from paralysis of respiratory centre.

Universal antidote

A definite antidote to H_2S cannot be suggested but a "Universal antidote" can be tried. Universal antidote can be used to treat whenever the actual character of a poison is unknown. The constituents of a universal antidote are harmless and can inactivate many poisons by physical and/or chemical means. A generally accepted composition is; powdered charcoal-2 parts, light magnesium oxide—1 part and tannic acid—1 part. 15 gm of the mixture is administered in a glass of warm water. Powdered charcoal—an adsorbent of poisons—acts mechanically; magnesium oxide is an antacid, while tannic acid precipitates protein tannate film that serves as a mechanical protective. A mixture of the three is effective against heavy metal poisoning, acids, bases, alkaloids, etc. For a wider range, the universal antidote used possesses following composition, each in 1 part

$Mg(OH)_2$—as alkali
Charcoal—as adsorbent
$MgSO_4$, Na_2SO_4—as precipitant and laxative
$KMnO_4$—as oxidant
NaCl—as emetic

Lead poisoning

Lead is an excellent astringent (stops bleeding), but because of high toxicity its use is not expedient. Lead poisoning among children is quite common due to their intake of flakes of paints. It also occurs due to lead vessels employed in industry. Lead poisoning is insidious and slow. Inorganic lead is not absorbed through smooth skin, but is readily absorbed through ruptured skin. However, the organic tetraethyl lead can even penetrate skin.

Lead is a cumulative poison. It is deposited within the bone struc-

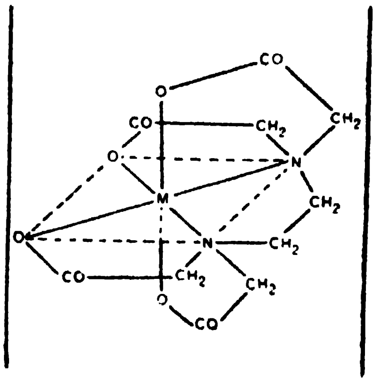


Fig. 3. EDTA-metal complex

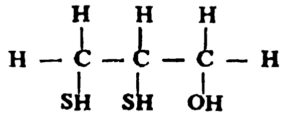
ture on sites ordinarily occupied by calcium ions. Retention of lead is related to the pH of body fluids. Lead poisoning can affect (i) kidney function, (ii) the central nervous system, and (iii) can cause anemia. Lead interacts with SH groups of enzymes responsible for synthesis of heme, which in turn is responsible for formation of red blood cells. Lead poisoning in small children is far more dangerous than in adults.

A preliminary symptom of lead poisoning is a blue line on the edge of gums. For treatment of lead ingestion, the stomach must be first emptied by a laxative. Milk of eggs and coffee should then be taken. Accumulated lead is released by calcium disodium salt of ethylenediamine tetra - acetic acid (EDTA). Since disodium EDTA penetrates through cells and is toxic to kidney, calcium disodium EDTA is used (Fig. 3).

Arsenic poisoning

Arsenic is highly toxic. Symptoms of arsenic poisoning may be prominent even after twelve hours of ingestion. They include constriction of throat, difficulty in swallowing followed by acute gastrointestinal pain and vomiting tendency.

Treatment involves an initial saline laxative followed by a dose of magnesium oxide and ferric hydroxide. The magnesium compound increases pH of the gastric fluids so that insoluble iron (III) arsenite is precipitated. To remove arsenic from sulphydryl group (SH) of enzymes, dimercaprol is administered.



$$\mathrm{H-\overset{H}{\underset{SH}{C}}-\overset{H}{\underset{SH}{C}}-\overset{H}{\underset{OH}{C}}-H}$$

(dimercaprol)

If poisoning is severe, doses as high as 5 mg/kg body weight should be given at four hours' interval during the first 24 hours.

Mercury poisoning

From the days of alchemy, mercury has been used for various medicinal purposes. Mercury compounds were employed as antifungal disinfectants. Nearly all mercury compounds are applied externally as ointment. Out of all mercury compounds, mercury (II) compounds are highly toxic. Acute mercury poisoning is commonly caused by mercuric chloride or mercuric cyanide. Whenever mercury (II) chloride is ingested, the earliest evidence of its toxic action may be an ashen grey appearance of the face caused by the precipitation of protoplasm of mucous membrane. The condition is very painful.

For treatment of mercury poisoning, first the mercury compound which has not yet been totally absorbed from the intestinal tract is removed by some emetic, e.g., sodium chloride. Then protein, preferably in the form of milk or raw eggs, is fed so that it can form a coating in the stomach to prevent further absorption of mercury. After that dimercaprol or penicilamine is injected by intramuscular route to inactivate the mercury absorbed in tissue.

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STRONGER GLASSES

(*Continued from page 334*)

crack propagation. All such attempts, however, must not destroy transparency of glass which after all is the most remarkable and admired property.

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HOW SPERMS ARE FORMED

P. C. GANGWAR

SPERMATOZOA are produced in the seminiferous tubules in testes. They develop from the spermatogonia of the germinal epithelium found at the outer margin of the tubules. Growth of the tissue by a series of cell divisions, is toward the lumen of the tubules. The outline and the characteristics of the cells change and they are eventually freed from the surrounding tissue. After a period of attachment to "nurse cells" the spermatozoa become independent and pass along the tubules towards the collecting ducts. The entire process of spermatozoa formation is known as spermatogenesis.

Little is known about the chemical nature of the developmental factors which control the successive stages of cellular transformations during spermatogenesis

Spermatogenesis includes two major phases. The first phase, meiosis, involves growth of division which reduces the chromosome number from diploid to haploid (from 60 to 30 in cattle). This, in turn, is followed by another simple cell division which doubles the number of developing cells. This phase of spermatogenesis is known as spermatocytogenesis. It ends with the formation of spermatids and is of primary interest to geneticists. It is in the reduction division that the allelic genes responsible for the inheritance of characteristics, and carried by the chromosomes, are distributed randomly among the spermatozoa. A similar reduction division occurs in ovum formation. So, when the two haploid cells unite at fertilization, the diploid chromosome number, characteristic of the species, is restored.

The second phase of spermatogenesis is of particular interest to students of reproductive physiology. The spermatids undergo a metamorphosis in shape, which results in completely formed spermatozoa. The changes include formation of the acrosome, the head, the midpiece, and the tail of the spermatozoa, and of their constituent parts from the various cellular materials. In the formation process a part of the cytoplasm of the spermatid is excluded from the final sperm cell, and it becomes the cytoplasmic droplet which is characteristic of an immature spermatozoon. During maturation the sperm cell attaches to the Sertoli or the so-called nurse cells arising from the basement membrane of the seminiferous tubule; thus attached, it appears to receive nutrient until it is detached into the lumen of the tubule and begins its journey through the excurrent ducts.

The process of spermatogenesis is controlled by the endocrine system. The hormones concerned are the gonadotropins; follicle stimulating hormones, which initiate spermatogenesis; interstitial cell stimulating hormone which initiates production of testosterone; the male hormone itself and probably the hormones of the adrenal and other glands. The functioning of the epididymis, the tone of the excurrent-duct system, and the secretory activity of the accessory glands are also dependent on the presence of male hormone in the blood stream.

From the seminiferous tubules the spermatozoa are moved by internal

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pressure though the rete-testis and the vasa efferentia to the single epididymis. In the epididymis, the cells undergo a process of maturation. By the time epididymal contractions have carried the spermatozoa to the cauda (tail) they acquire the ability of independent motility and the ability to fertilize ova. Spermatozoa remain fertile in the epididymis for a relatively long period as compared to the length of fertile life when they are in the female tract.

Spermatozoa are ejaculated by muscular contractions beginning in the vasa efferentia and involving all of the excurrent ducts and accessory glands.

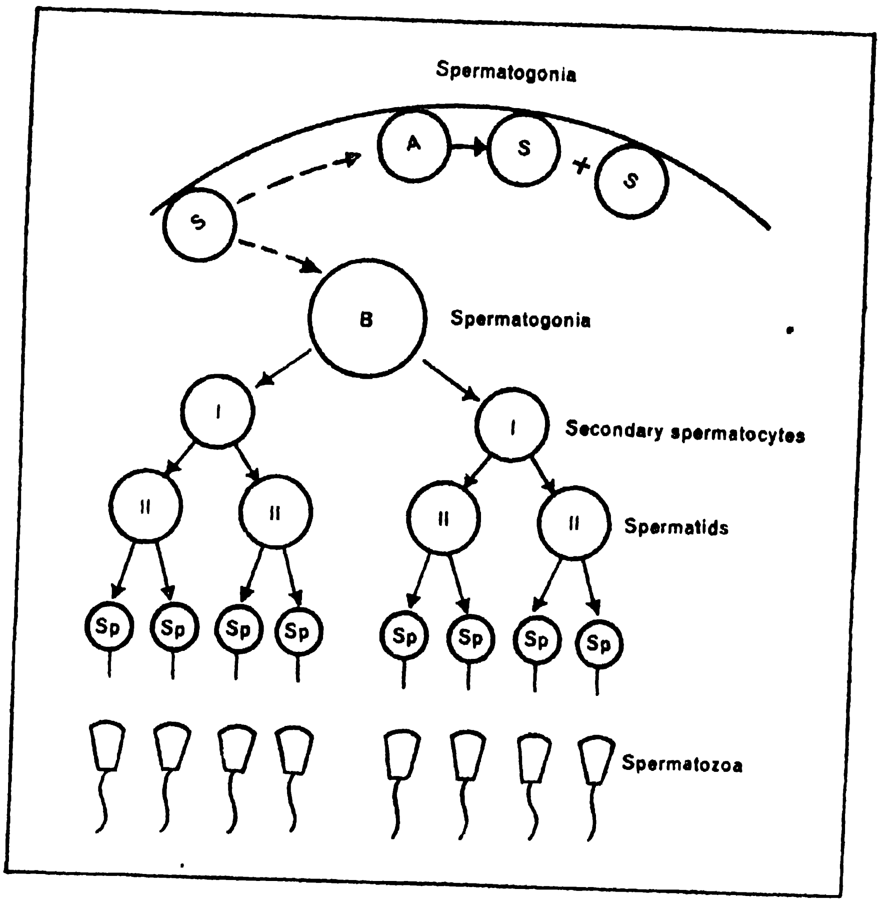


Fig. 1. Formation of spermatozoa (diagrammatic)

Effects of androgen

Androgens exert their action on the testis, indirectly through the pituitary and directly on the seminiferous tubules. The action of androgens on the testis is dependent upon the age at which hormone administration is started, the dosage employed, the androgen used, the duration of the treatment, and the species of the test animal. Androgen, when given to normal male rats, may either stimulate or depress spermatogenesis. The type of effect varies with the dose and the age of the animal. If administered immediately after hypophysectomy (pituitary removal), the hormone will prevent tubular atrophy and will maintain spermatogenesis. The evidence is therefore valid that at least in this case animal androgen plays a part in the sustenance of the testicular tubules. In the normal human male, ordinary therapeutic (curative) doses actually depress the sperm count. It is probable that, although a normal amount of circulating androgen is beneficial and certainly not harmful to the tubular epithelium, the excess amount which accrues from injected hormone added to the normal endogenous supply may suppress the secretion of pituitary gonadotropic hormone (FSH) which normally serves to support tubular integrity.

If occasional cases of sperm inadequacy exist which are due to an inadequate supply of androgen it would be anticipated that male hormone would be beneficial. One would expect this type of case to be characterized clinically by the usual eunuchoid features which are associated with androgen deficiency. Several cases of hypogonadotropic eunuchoidism have been reported in which androgen therapy has led to the appearance of sperm in the ejaculate. In some of these patients spermatogenesis was known to have been absent before therapy. Whether in such cases androgen exerts a direct effect on tubular maturation or simply acts as a trigger to initiate pituitary activity cannot be said with certainty. The failure of the low urinary gonadotropin to rise in some of these cases is suggestive of a direct tubular effect. In other instances where spermatogenesis has persisted after therapy has been withdrawn, a trigger mechanism is suggested. There are several cases on record in which low sperm counts were seen to rise during therapy in individuals who were not frankly described as eunuchoid. Such an effect, however, has not been commonly observed.

Heller and coworkers (1950) have demonstrated a remarkable rebound of spermatogenesis when androgen was given to men who showed oligospermia (few sperms) but whose endocrine status appeared normal. During the period testosterone propionate was being given in a dose of approximately 50 mg three times a week for 1 to

3 months, the sperm count was further reduced to levels of azoospermia (no sperms) and biopsies revealed a more severe derangement of germinal elements than before. There was tubular necrosis with hyalinization, and disappearance of Leydig cells. Gonadotropin excretion declined. Within 5 to 6 months after discontinuance of androgen, the sperm counts rebounded far above pre-treatment levels in approximately half the cases, whereas testicular biopsies showed recovery from the depression which followed androgen administration. This improvement was still apparent two years later, in some instances; but in others recession occurred several months after the peak of the rebound.

Biochemical changes

Spermatozoa originate in the testis in the course of spermatogenesis from the germ or spermatogenic cells of the seminiferous epithelium. It is a process of stepwise proliferation and transformation, distinguished by the successive stages of spermatogonia, primary spermatocytes, secondary spermatocytes and spermatids. The only non-germ cell in the seminiferous tubule is the supporting 'nurse cell' or Sertoli cell.

Mammalian spermatogenesis consists of two clearly defined phases; spermatocytogenesis and spermiogenesis. First, the spermatogenium develops mitotically into a number of primary spermatocytes; the primary spermatocyte then undergoes meiosis which leads via two diploid secondary spermatocytes to the formation of four haploid spermatids, the number of chromosomes in each being reduced by half. Of the four spermatids, two carry the X chromosome, and the remaining two, the Y chromosome. Next, during spermiogenesis by a process of transformation known as spermateliosis, the four spermatids differentiate into spermatozoa, two female determining (X), and two male determining (Y). The main stages of spermateliosis are (i) the golgi-phase, during which the pro-acrosomic granules arising in the golgi apparatus fuse to form the pro-acrosome; (ii) the cap-phase, in the course of which the pro-acrosome separates from the golgi apparatus and assumes the form of a cap over the anterior part of the nucleus; (iii) the acrosome-phase, involving the transformation of the pro-acrosome into the acrosome proper, with the nucleus becoming more condensed, the bulk of the cytoplasm migrating posteriorly towards the region of the future middle piece and tail; and (v) the maturation phase, or final transformation of the spermatids, following which the early, as yet functionally immature, spermatozoa are released into seminiferous tubules.

Little is known about the chemical nature of the developmental factors, possibly hormone-like in nature, which control the successive stages of cellular transformations during spermatogenesis. In this respect reference may be made to the so-called 'volatile factor' of insects; this was thought to play a decisive role in the *in vitro* differentiation of insect spermatocytes to spermatozoa. However, after much study, the elusive factor was identified as water, and the volatility was accounted for in terms of loss of water, such as occurs in the culture of spermatocytes as a result of ventilation (Ketchel and Williams, 1955).

So far the biochemical changes accompanying spermatocytogenesis and spermiogenesis have been mainly studied by histochemical methods In several cases special spermatogonia and spermatocytes have been shown to have a cytoplasm which is basophilic, different from mature spermatozoa which exhibit only a faint basophil colouration of the flagellum. Cytochemical studies carried out by Brachet (1947) has shown that the affinity of the spermatogonia and spermatocytes for basic dyes is due to ribonucleic acid. Cytochemical as well as spectrophotometric studies (Caspersson, 1939) point to the fact that spermatogenesis involves a progressive disappearance of ribonucleic acid from the developing sperm cell. In ejaculated bull spermatozoa, Vendrely and Vendrely (1948) using the analytical methods of Schmidt and Thanhauser (1945) and Schneider (1945), found a content of 0.2×10^{-9} mg ribonucleic acid per sperm cell, that is fifteen times less than the corresponding values for deoxyribonucleic acid. Similar results, all agreeing on the virtual absence or the presence of traces only of ribonucleic acid, were obtained with human, rat and bull spermatozoa. The biochemical processes which cause first the appearance of ribonucleic acid in the spermatogonia, and next its disappearance from the spermatids, are not well understood at present. The disappearance of ribonucleic acid during the later stages of spermatogenesis has been studied among others in the rat. Ribonucleic acid is detectable in the early rat spermatids, scattered in the form of small cytoplasmic particles. Later, however, during the acrosome phase of spermateliosis, these small particles aggregate into coarser granules which are eventually released by the spermatids; some disintegrate, while others are probably absorbed by the germinal epithelium.

Two other processes associated with spermatocytic development are: the progressive decline of phosphatase activity in the nuclei, and a simultaneous disappearance of glycogen. No less than three phosphatases namely acid phosphatase, alkaline phosphatase and 5 nucleotidase, are said to disappear in the course of the transformation of the spermatids into spermatozoa. As yet, however, these phenomena are poorly understood, resting as they do almost exclusively on histochemical studies. They do not always take into account the possibility that changes in staining intensity and pattern obtained by histochemical procedures may be the reflection of altered permeability of the cell rather than the result of true variations in enzyme concentration.

Both the Sertoli cells and the spermatogonia of man and certain other mammals abound in glycogen, which also occurs, though in a smaller concentration, in the primary spermatocytes. But the secondary spermatocytes and the spermatids give practically no cytochemical reactions for glycogen; in the mature spermatozoa the glycogen content is exceedingly low. In ejaculated ram semen 'glycogen', i.e., the alkali resistant polysaccharide which behaves like glycogen on ethanol-precipitation and yields glucose on hydrolysis (as determined by glucose oxidase) seldom exceeds 0.1% and may be as little as 0.019 (Mann, 1956).

Yet another phenomenon accompanying spermatogenesis is a significant change in the distribution of lipids which involves both the germ cells and Sertoli cells. A large amount of cholesterol-positive lipid is characteristic of the seminiferous tubules in seasonally breeding birds at the end of the breeding season, but usually it disappears at the time when the next season's spermatogenesis is about to begin (Marshall, 1955). In certain invertebrates, as for example, Lithobius (Monne, 1942), lipids form a highly characteristic component of the cytoplasm in spermatocytes. These cytoplasmic lipids are usually birefringent (the refraction of light in two slightly different directions to form two rays and give positive reactions to steroids. In ejaculated spermatozoa, at any rate those of mammals, the lipids are confined largely to certain definite regions such as the mitochondrial sheath of the middle piece and the so called lipid capsule.

Mammalian spermatozoa emerging from the testis must pass through the epididymis before they become fully mature and ready for ejaculation. The time span required for the completion of spermatogenesis in the testis and sperm passage in the epididymis was successfully investigated by the application of radioactive isotopes. Autoradiography in particular has often been used to 'time' the various stages of spermatogenesis. In this way it became possible to establish differences in the rate of uptake and retention of radioactive isotopes by spermatocytes and other cells associated with the spermatogenic cycle. In man injected intratesticularly with tritiated thymidine, autoradiographic examination of tissue obtained by testicular biopsy revealed the presence of labelled midpachytene spermatocytes after 16 days, and immature spermatids after 32 days after injection; the whole process of sperm formation probably requires about 64 days (Heller and Clermont, 1963).

Other animal species on which studies were made concerning the duration of spermatogenesis and epididymal passage of spermatozoa included the rat, rabbit, ram, boar and bull. When bulls were injected with (P^{32}) inorganic phosphate and the radioactivity measured separately in ejaculated spermatozoa and the seminal plasma, it was seen that the content of the isotope rises much more speedily in the seminal plasma than in spermatozoa. Peak activity values have been recorded in bull seminal plasma at 11-14 days after isotope administration; in the deoxyribonucleic acid of epididymal spermatozoa radioactivity appeared at approximately 41 days; in ejaculated spermatozoa at about 49-52 days, highest values having reached at 60 days. It may be added that changing the frequency of collections of semen in the bull seems to have little effect on the duration of the process of sperm formation in the testis, sperm passage through the epididymis, which requires on an average 11 days when semen is collected from bulls at 2-3 days interval, can be speeded up significantly by increasing the rate of collections.

When bull spermatozoa are suspended in Tyrode's solution and exposed to (P^{32}) phosphate, a 'pick-up' of radioactivity occurs within a few minutes; the phosphorus which has entered the sperm cells in this manner remains in acid-soluble form and is not incorporated into the intracellular sperm protein constituents (Bishop, 1950).

The fact that spermatozoa appear in the ejaculated semen only some weeks after their formation had been initiated in the testis is both of biochemical as well as clinical interest. Clearly, abnormal sperm morphology, or a chemically detectable abnormality in sperm composition observed in a freshly collected ejaculate, may reflect events which had taken place in the testis several weeks earlier and must not be taken as indicator of what is happening in the gametogenic testicular tissue at the time of semen collection and analysis.

Information gained from the experiments on the timing of the various stages of spermatogenesis has also been utilized to pin point spermatogenic phases which are particularly vulnerable to the action of various parenterally or orally administered antifertility drugs. One can reason that a drug which interferes with either epididymal spermatozoa or spermatids will produce a sterile ejaculate sooner than an agent which acts on spermatocytes or spermatogonia. An approach of this sort, combined with

(*Continued on page 358*)

SCIENCE SPECTRUM

Underground nuclear explosions

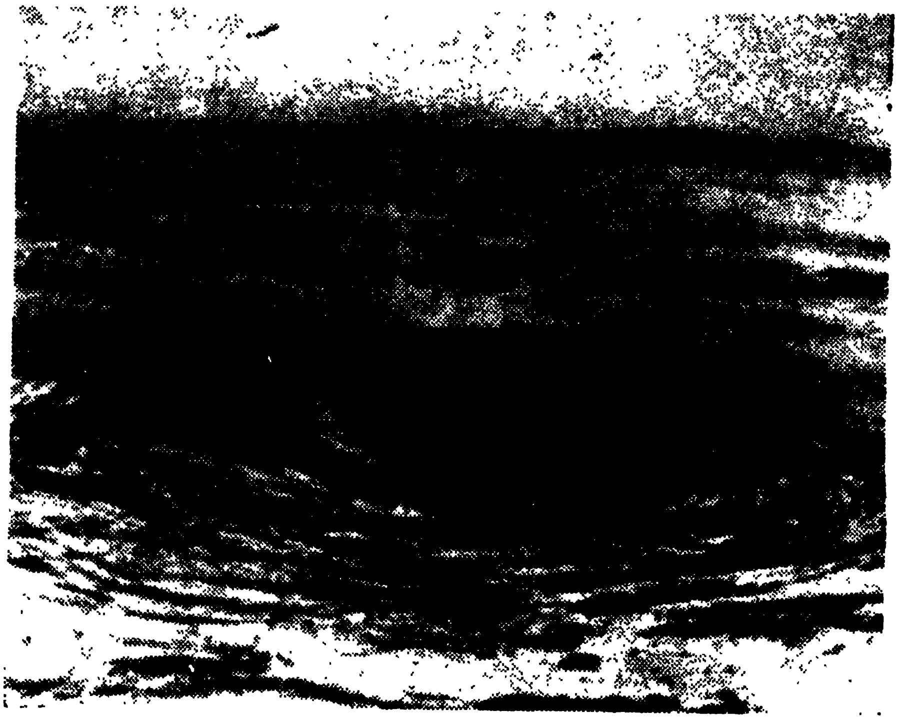
A NUCLEAR explosion generates temperatures as high as a million degrees and creates air pressures greater than one million atmosphere. In addition to the intense heat and air blasts, an atmospheric explosion also spews out vast amounts of radioactive material that stays in the atmosphere for several months. The existence of lethal radioactivity for a long period makes the atmospheric testing of the nuclear devices even in remote areas of the world a dangerous venture. An effective way of minimizing the radioacive hazards is to carry out nuclear tests in deep underground cavities.

The USA, UK and the USSR have conducted a large number of underground detonations during the late fifties and the early sixties. In the course of these tests, it was found that radioactive substances released at the time of the explosion were completely confined to the subterranean rocks and there was no risk of their fallout affecting living beings. Encouraged by the cleanness of these underground blasts, the big powers have carried out a large number of such tests to study the various military and civilian applications of nuclear explosions.

In the first American underground test, a 1.7 kiloton nuclear device was exploded in the Nevada testing grounds at a depth of about 300 meters. The shot was placed in rocks of volcanic origin called 'tuff'. This explosion produced a spherical cavity of 18-meter radius and the sides of the cavity were found to have been lined with a 10 cm thick glass formed out of the molten rock. Due to the blast, the surrounding rocks upto a radius of 90 meters were also badly crushed.

About a minute after explosion, the broken rocks started caving in and the cavity finally took the shape of a long rubble-filled chimney. Almost all of the radioactive material formed during the explosion was found to be contained in the rubble and the glass of the collapsed hole. The high temperature generated at the time of the explosion lasted for less than a millionth of a second and the heat was barely felt at a distance of a hundred meters. The temperature in the cavity dropped rather quickly to the boiling point of water and the heat diffused only slowly outwards.

The ground motion due to explosion was not noticed by people living at a distance of more than 5 km. Immediately above the cavity the vertical displacement was approximately 2.5 cm and the acceleration was found to be around six times the gravity value. An electronic recording station and a ventilation blower system for the tunnels situated at a distance of 900 metres from the site did not suffer any structural damage due to the explosion. The air blast effects were negligible and the explosion was not audible beyond a few kilometers. Some individuals have, however, recollected hearing



The 150 m diameter crater formed after the underground nuclear explosion in Rajasthan desert a dull thud when later told of the test.

During the years 1957 and 1958, the USA alone conducted more than eight underground tests. Based on these data scientists have prepared suitable charts from which one can predict the size of the cavity, the amount of rock crushed, and the quantity of radioactivity that is expected to be released by an explosion of known yield.

Though the motion of the ground in the vicinity of the explosion is not significant enough to be felt by the people, these detonations are easily detected by sensitive seismographs placed even at distant places. To evade detection, however, (as may happen in the case of clandestine explosions) the device may be placed in cavities that are suitably modified. Called the 'decoupling' techniques, the methods employed for muffling the underground explosions are of various types.

In one system, the nuclear device is exploded in a cavity much bigger than the predicted size. It is found that by this device, the ground vibrations can be reduced by a factor of four to five. Similarly, when the explosive is placed in an enclosure surrounded by water, the water absorbs most of the energy released by the explosion and the ground movements are reduced to a large degree.

Placing of the device in a cavity made out of hard rock such as granite is also useful in decreasing the intensity of the shock waves. Under these conditions, the explosion breaks the surrounding rocks into pieces and in this process a large portion of the energy is absorbed near the cavity itself.

The recent underground nuclear explosion by India in the Rajasthan desert had an yield of about 15 kiloton. Basically, it was aimed at further evaluating the effects of such explosions on rock formations and the prospects of their application for peaceful purposes.

G. ETHIRAJULU

Positron annihilation

POSITRON, the anti-particle of electron, was predicted by P.A.M. Dirac in 1930. It was experimentally detected in 1932 by Anderson, Blackett and Occilianini. Electron and positron being anti-particle of each other annihilate each other when they come in close vicinity and radiate energy in the form of γ-rays. This process is known as positron annihilation. In recent years, study of positron annihilation has provided valuable information regarding the nature and properties of matter.

In any medium (solid, liquid or gas), the positron is quickly slowed down and comes to rest before it is annihilated. The most common process of annihilation occurs with the emission of two or three photons of γ-rays. The properties and the number of the emitted photons depend on the relative spins of the interacting particles. It has been found that in order to conserve momentum, energy, parity, etc., two photons are emitted when the spins of the particles are anti-parallel to each other. When the spins of the two particles are parallel, three photons are emitted. In the case of two-photon annihilation, each photon carries an energy equal to 511 Kev (if the annihilating pair is at rest) and they are emitted at 180° to each other. In case of three-photon annihilation the total energy of the annihilating pair is shared by the three photons emitted in one plane.

The process of annihilation, as discussed above, is termed as direct annihilation. However, a bound state annihilation of the e^+—e^-pair is also possible. Electron and positron can form a bound atomic system and then annihilate from this bound state. This bound system is a quasi-stable system and has a structure similar to that of the hydrogen atom; the proton nucleus in hydrogen being replaced by a positron. The possible existence of such a bound state was first suggested in 1934 and was later named "positronium".

The metastable atom of positronium has properties similar to those of the hydrogen atom. The main difference comes from the reduced mass of the e^-—e^+ pair, which lowers the energy levels by a factor of 2. For example, the binding energy of the positronium atom (6.8 ev) is half the binding energy of H-atom (13.6 ev).

Like hydrogen atom, positronium atoms can be formed either in a para-state or ortho-state depending upon whether spins of the electron and the positron are anti-parallel or parallel. Para-positronium decays into two photons, whereas ortho-positronium decays into three photons. In the ground state, positronium is an admixture of the ortho and para states.

Factors governing positronium formation

Positronium formation in a medium depends upon many factors like the electron density, space available in the medium to accommodate the positronium atoms, etc. Experimental evidence shows that positronium formation is favoured in molecular materials, liquids, amorphous solids, gases and disordered systems, whereas it is not formed in metals, ionic crystals and other crystalline substances. In metals the large electron density makes direct annihilation the most probable process, thus inhibiting positronium formation. In ionic solids, positrons decay by forming complexes with the anions of the crystal of the type (e^+-Cl^-) or (e^+-Br^-), etc. In crystalline materials the regularity in structure does not leave enough space to accommodate a positronium atom. On the contrary, in liquids, disordered systems and amorphous solids, there is enough room (free volume) available that makes formation of positronium more probable in these substances.

Apart from these restrictions the energy of the positron is another important factor in deciding positronium formation. The formation of positronium needs the removal of an electron from the molecule of a gas. For this the minimum energy the positron should have is the ionization potential of the gas molecule. It has been calculated that the threshold energy for positronium formation is (6.8 ev). Above this energy all positrons should form positronium atoms.

Applications in solid state physics

The lifetime for the three-photon annihilation process is much longer than the lifetime for the two-photon process. The decay rate (inverse of lifetime) is therefore very slow for the former as compared to the decay rate for the latter process. However, during collisions of the positronium atom with the surrounding medium the positronium can change from ortho to para state, resulting in faster decay by two-photon annihilation. All such processes which lower the lifetime of ortho state by converting ortho states into para states are termed as "quenching processes". The lifetime of the positronium due to these quenching processes is of the order of a few nano-seconds (10^{-9}). Measurement of this time period is of great significance in understanding many solid-state properties.

K.P. SINGH

Affinity chromatography

AFFINITY chromatography is a recent addition to the various techniques used for the purification of a variety of macromolecules such as enzymes, antibodies, antigens, etc. Affinity chromatography is carried out by immobilizing one of the components of the interacting system (the ligand) to an insoluble support. Crude solution containing the macromolecule is passed through a column packed with selective adsorbents, specific for the particular macromolecule to be purified. A complex is formed through the ligand with the macromolecule; other molecules not exhibiting affinity for the ligand pass down the column. Proper eluant medium can then displace the retained enzymes from the column.

The advantages of affinity chromatography are the rapidity and ease of procedure as well as the fast separation of the protein to be purified from inhibitors and destructive contaminants, such as proteases. This technique stabilises protein structure by ligand binding at the active site and thus protein denaturation during purification can be prevented. The separation of soluble and solid components by centrifugation or filtration makes it possible to reuse the same adsorbent. In some cases affinity chromatography has been used to isolate high purity enzymes from a crude mixture and thus bypassing a number of intermediate steps.

An ideal water-insoluble carrier used for affinity chromatography of enzymes should possess following properties:

(i) it should have very weak interaction with proteins so that non-specific adsorption of proteins is minimized,

(ii) liquid flow through the matrix should be good,

(iii) it must possess chemical

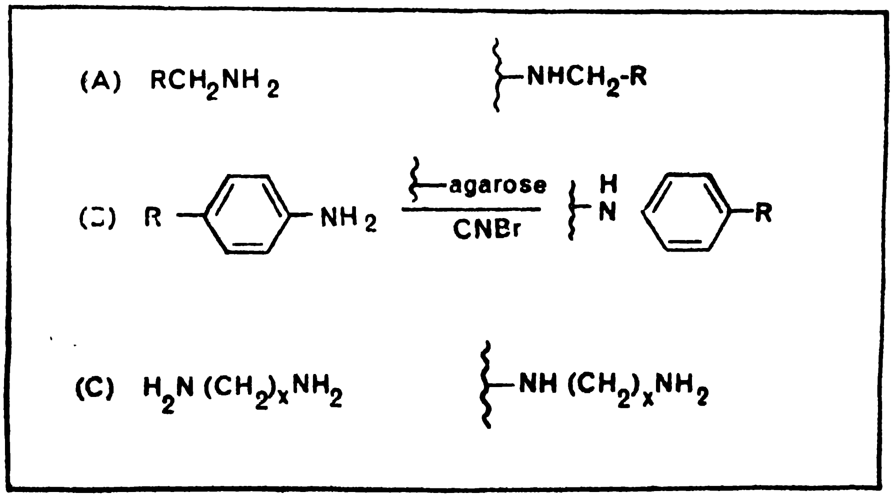


Fig. 1

Table 1. Some enzymes purified by affinity chromatography

Enzyme	*Ligand*	*Insoluble matrix*
Tyrosinase	Aminophenol	Cellulose
Flavokinase	Flavins	Cellulose
Carboxypeptidase A	L-Tyrosine-D-tryptophan	Agarose
β-galactosidase	*p*-Aminophenyl thio-galactoside	Agarose, Polyacrylamide
Tyrosine amino-transferase	Pyridoxamine phosphate	Agarose
Pyridoxal kinase	Adenosine diphosphate	Agarose
Alcohol dehydrogenase	NAD	Porous glass

groups which can be activated or modified so that chemical linkage of a variety of ligands is possible,

(iv) its stability should be unchanged when subjected to coupling and various conditions of pH, ionic strength, temperature, and presence of denaturants (e.g., urea and guanidine hydrochloride) and detergents which are needed for adsorption or elution, and

(v) it should form a very loose and porous network so that uniform entry and exit of large molecules throughout the matrix is possible.

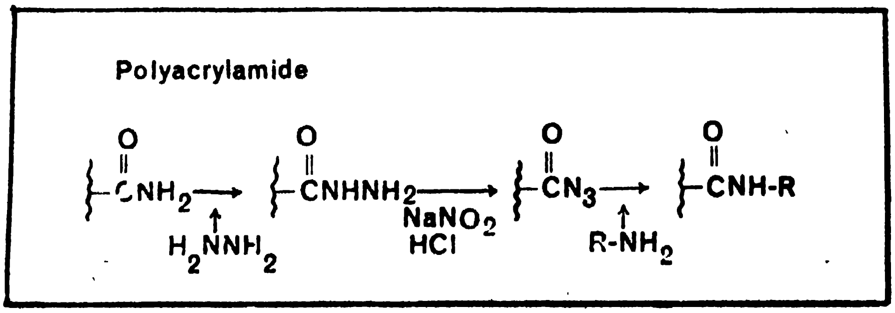
Various water-insoluble carriers such as cellulose derivatives, polystyrene or synthetic polyamine acids have been used. But beaded agarose derivatives possess many of the properties of an ideal carrier. Synthetic polyacrylamide gels have also been used but they are inferior to agarose when used for enzyme purification. However, for intact cell separation acrylamide beads are more useful. Inorganic carriers such as porous glass beads are sometimes preferred since they are resistant to microbial attack, to dissolution by organic solvents and configurational alteration resulting from changes in pH or buffer composition. The disadvantage of glass beads is that they do not permit easy entry or exit of large macro molecules. The non specific adsorption of proteins to glass surface is also a serious problem. However, glass beads are very useful for ligand highly insoluble in water.

The small molecule, to be covalently linked to the solid support for the preparation of selective enzyme adsorbents, must have special affinity for the macromolecule to be purified. A substrate may be used if it binds to the enzyme under some conditions deterrent to catalysis, e.g., at low temperature, at a pH other than at which catalysis can occur, or in the absence of metal ion.

Various methods are available for the fixation of ligands to insoluble supports but covalent attachment is generally useful. In the covalent procedure chances of desorption of ligand from the solid support are minimum.

The most common example of covalent linkage of enzymes and antigens to cellulose and polystyrene derivatives is the reaction of histydyl and tyrosyl residues of these proteins with diazotized derivatives of the matrix. Antigens are now commonly coupled to diazonium cellulose and diazotized poly-*p*-aminostyrene. Antigens have also been coupled by their amino groups to carboxymethyl cellulose (CMC) with dicyclohexyl carbodiimide in organic solvents. Proteins can be attached through their amino groups to insoluble polystyrene and cellulose supports by reactions involving acyl halides, acid anhydrides, acyl azides and sulfonyl chlorides.

Beaded agarose derivatives, besides increasing the general versatility of affinity chromatography, prove especially useful in cases where amino groups are not present on the ligand, and where it is desirable to remove the intact protein-ligand complex by specific chemical cleavage of the ligand-matrix bond. Coupling of ligands containing primary amino groups to agarose by the cyanogen bromide procedure as shown in Fig. 1. Aliphatic diamines of the general formula $NH_2\ (CH_2)_x\ NH_2$ (e.g., ethylene diamine, hexamethylene diamine) can be attached by one of the amino groups (with little cross-linking) by cyanogen bromide procedure. This way it is easy to insert extensions of considerable length, depending on the nature of $(CH_2)_x$. Ligands containing carboxyl groups can be coupled directly to amino agarose with a water-



$$-\overset{\overset{O}{\|}}{C}NH_2 \xrightarrow[H_2NNH_2]{} -\overset{\overset{O}{\|}}{C}NHNH_2 \xrightarrow[NaNO_2,\ HCl]{} -\overset{\overset{O}{\|}}{C}N_3 \xrightarrow[R\text{-}NH_2]{} -\overset{\overset{O}{\|}}{C}NH\text{-}R$$

Fig. 2

soluble carbodiimide.

The procedures for polyacrylamide derivatization involve conversion of the carboxamide side groups to hydrozide groups which, in turn, are converted with nitrous acid into acyl azide derivatives. The latter react rapidly with compounds having aliphatic or aromatic primary amino groups without intermediate washings or transfers (Fig. 2).

Affinity chromatography has been used for different purposes such as purification of enzymes, antibodies. antigens, nucleic acids, vitamin, various proteins, drug or hormone receptors, peptides and intact cell populations. It can also be used for the concentration of dilute protein solutions as well as separation and resolution of protein components.

PURNENDU GHOSH
VINOD BIHARI
REETA BOSE

Better indicators for acid–base titrations

THE use of indicators in acid-base titrations depends on the fact that they exhibit different colours depending on the pH of the solution. The change from an 'acid' colour to an 'alkaline' colour takes place within a small interval of pH. This interval, usually extending over two pH units, is called the colour-change interval of the indicator. The proper selection of an indicator is made by examining the titration curve showing the changes in pH during the course of the titration. The change in pH in the vicinity of the equivalence point is of great importance as it is on this basis that the selection of an indicator is made.

In certain cases it is preferable to have a more pronounced colour change over a narrow range of pH, e.g., the titration of phosphoric acid to the dibasic stage (equiv. point at $pH = 8.7$). Owing to extended hydrolysis, the titration cannot be performed except with an indicator of a very narrow range. Similarly titration of a carbonate to the bicarbonate stage (equiv. point at $pH = 8.3$) presents some difficulty. In such cases the purpose is served by what are termed as 'screened indicators' and 'mixed indicators'. The former consists of a combination of an indicator and an inert dye, while the latter is a mixture of two indicators.

Ideally, the two limiting colours of any two-colour indicator should be fully complementary so that at some pH within the transition range a grey colour develops. Normally the indicator concentration being low, the solution attains a very faint grey colour that is hardly perceptible. The end-point corresponds to the change from one colour to its complementary colour, passing through a colourless stage. Such an ideal condition is realized when, for example, we have red and its exactly complementary, green, as limiting colours. In practice, however, it is extremely difficult to find limiting colours that are fully complementary. If we have a dye that is inert in the pH rage cf our interest, we can use it as a screen against which or through which the actual colour change is observed. Such an indicator is termed a 'screened indicator'. The inert dye must be properly selected with respect to its colour, and mixed in the right proportion with an indicator. The colour change then observed is from one colour to its complementary colour or close to it, e.g., a blue dye will screen an end-point change from red to yellow because in combination with red it gives violet colour whereas with yellow it yields green colour. The end-point is an intermediate grey. Taking the particular example of methyl orange, the colour change is yellow to red as we go from alkaline to acid medium in the pH range 4.4-3.1. The detection of the end-point becomes easier and more precise if an inert dye, xylene cyanol FF, is used alongwith methyl orange. The intermediate grey stage is at pH 3.8. The colour change from the alkaline to the acid stage is green-grey-magenta. The appearance of grey is a clear warning that the end-point is near.

Mixed indicators are obtained by mixing two indicators (having close pK_{IN} values) that undergo colour transition in approximately the same pH range. If the two indicators are judiciously selected with regard to colour and are mixed in correct proportions, the solution becomes grey or colourless at the end-point and the colour change is sharper than with either indicator alone. A typical example is the titration of a carbonate to the bicarbonate stage. In many laboratories phenolphthalein is used as an indicator for this titration. The end-point is given by the disappearance of the pink colour. A large error results owing to the fact that disappearance of a colour is more difficult to detect. An ideal choice would be a mixed indicator consisting of thymol blue and cresol red which changes from yellow to violet at pH 8.3. Similarly a mixture of phenolphthalein and alpha-naphtholphthalein is preferable in the titration of phosphoric acid to the dibasic stage; the colour changes from pale blue to violet at pH 8.9.

Table 1 lists some 'screened' and 'mixed' indicators along with single indicators for comparison. Many such combinations can be chosen among various indicators so that

Table 1. Screened and mixed indicators for acid-base titrations

S. No.		*Indicator*	pK_{In}	*pH visual transition interval*	*Colour*		*Composition*
					Acidic	*Basic*	
1.	(a)	Methyl Orange (M.O.)	3.7	3.1-4.4	Red	Orange	—
	(b)	M.O.+Xylene Cyanol FF	—	3.8-4.1*	Violet	Green	5:7 of 0.1% solns. in 50% alcohol.
2.	(a)	Bromo Cresol Green (B.C.G.)	4.7	3.8-5.4	Yellow	Blue	—
	(b)	B.C.G.+M.O.	—	4.3	Orange	Blue-green	1:2 of 0.1% aq. solns. of sodium salt.
	(c)	B.C.G.+Chlorophenol red	—	6.1	Pale green	Blue-violet	1:1 of 0.1% aq. solns. of sodium salt
3.	(a)	Methyl red (M.R.)	5.0	4.2-6.3	Red	Yellow	—
	(b)	M.R.+Methylene Blue	—	5.3*	Red-violet	Green	1:1 of 0.1% solns. in 50% alcohol
4.	(a)	Phenolphthalein (Ph)	9.6	8.3-10.0	Colourless	Red-violet	—
	(b)	Ph.+Methylene Green	—	8.8**	Green	Violet	1:2 of 0.1% soln. in alcohol
	(c)	Ph.+α-naphtholphthalein	—	8.9	Pale-rose	Violet	3:1 of 0.1% solns. in alcohol
	(d)	Ph.+Thymol Blue	—	9.0	Yellow	Violet	1:3 of 0.1% solns. in 50% alcohol
	(e)	Ph.+Thymolphthalein	—	9.9	Colourless	Violet	1:1 of 0.1% solns. in 50% alcohol

* neutral grey at stated pH

** pale blue at stated pH

their pK_{In} values are close together and the overlapping colours are complementary at an intermediate pH value.

M.L. MALIK, M.S. SETHI
P.S. RAGHAVAN

Sight for the blind

THE results of a five-year long experiment reported in a recent issue of the American journal *Science* indicate the possibility of using television cameras to stimulate visual sensations in the brain so that a blind person can see. Dr. W.H. Dobelle and Dr. M.G. Mladejowsky of the Utah University in the USA, and Dr. J.P. Girvin of the University of Western Ontario, Canada, have reported that two blind volunteers, whose brains were stimulated by metal electrodes connected to a television camera, described visual sensation of seeing dots of light.

In this experiment an array of 64 platinum/Teflon electrodes were implanted in the visual cortex of the brains of two volunteers, aged 43 and 28, who have been totally blind for 28 and 7 years respectively. The electrodes were connected to a television camera, bypassing the retina, optic nerve, and other mechanisms by which the brain maps the visual sensations of a normal person. When dots of light were projected on to the television screen, the electrodes were stimulated with the help of a computer. When this happened both the volunteers reported "seeing" the dots of light. The younger volunteer, who lost his sight in the Vietnam war, reported even seeing dots of different sizes; and some dots appeared orange coloured to him.

Of the 64 electrodes implanted, only a limited number which could give a pre-designed sensation were stimulated. The duration of the stimulation was limited to one second at a time in view of the unknown possibility of brain damage with longer stimulations. While the younger volunteer could respond to 60 electrodes, the elder one could respond only to 43 electrodes.

In the course of the investigation the researchers selected simple patterns like a square and an inverted 'L' and projected them onto the television screen as light dots. Then a computor stimulated groups of implanted electrodes corresponding to the dots on the screen. When this happened, the younger volunteer described the patterns and drew them without any hesitation. But in a similar experiment the elder volunteer could not recognise the patterns.

Though the results indicate only a preliminary success and a host of problems have to be solved before the method can be practicable, at least these results indicate a proper direction for further work.

P.K. TATINENI

Learn while you sleep

THE idea of "sleep learning" first appeared in a book of science fiction written by H. Gernsback in 1911, with the bizzare title *Ralph 124—C41+*. Two decades later, Aldous Huxley in his famous book, *Brave New World*, described a scene at the Infant Nursery and Neo-Pavlovian Conditioning Rooms thus: "....While 80 little Beta boys and girls napped in a shuttered dormitory, a loudspeaker placed under each pillow insinuatingly whispered the afternoon lesson in elementary class consciousness."

In Huxley's time, fiction had a long lead over science as far as sleep learning was concerned. The picture has, however, changed dramatically since then. Hypnopaedia, the term coined by Huxley himself, has become a realm of scientific study and very little confusion remains regarding its cause and effect.

The human brain provides the clue to the understanding of hypnopaedia. Currents generated by the brain during waking and sleeping hours by the bioelectrical activity of the brain cells can be recorded graphically on paper. These recordings are known as electroencephalograms (EEG), just as similar recordings pertaining to the heart are called electrocardiograms (ECG).

The understanding of the phases through which we pass when we fall from full consciousness into a deep sleep resembling a coma, and how these stages are influenced by internal and external events is necessary for the study of hypnopaedia. External influences are dependent on environment and internal ones on events happening within the person sleeping.

Such an exotic subject like hypnopaedia has, naturally, given rise to quite a lot of theories and hypotheses, not all of them necessarily very scientific. The scientific foundation of hypnopaedia was laid down by the Russian scientist I.P. Pavlov and it is mainly on the Pavlovian theories that the present understanding of the subject is based.

The human brain is made up of an astronomical number of brain cells (neurons) whose main functional states are exitation and inhibition. These functional states are mainly responsible for the various stages a man passes through from fully awakened to the sleep state. The phasic stages of sleep have different sensitivities to external signals like sound, light, touch and change of temperature.

The bioelectrical activity of the brain during sleep is studied from currents recorded by a multi-electrode device fixed on the surface of the skull, so that activities of various cerebral areas are covered. The result, an EEG, presents the brain waves at different stages of sleep. Five distinct stages *A*, *B*, *C*, *D* and *E*, representing respectively (i) the alert waking stage, (ii) the relaxed waking stage, (iii) the dozing off stage, (iv) the light to medium sleep stage, and (v) the deep sleep stage, have been detected. These stages are clearly distinguished by the frequency and amplitude (voltage) of the brain waves as recorded in the EEGs.

There are four main types of brain waves, alpha (α), beta (β), delta (δ) and theta (θ), differing from each other in their oscillation frequencies (measured in cycles/second Hz) and amplitudes (measured in microvolts, μv,). The frequency ranges are α, 8-13 Hz,; β, above 13 Hz; δ , 0.5-3 Hz; and θ, 4-7 Hz. The voltages can be grouped into low (10-30 μ v), medium (30-75μv), and high (75-200μv).

The cyclic variations of the different phases of sleep can be divided into two broad types, i.e., orthodox and paradoxical sleep. The former is characterized by low frequency, high voltage, brain waves (δ and θ) while the latter by high frequency, low voltage ones (α and β). Since α and β waves are predominant during waking hours, the second type of sleep is called paradoxical.

Not all phases of sleep are suitable for hypnopaedic lessons rendered through tape recorders. The receptive states are most likely to occur in the initial phases, i.e., between *A* and *C* of sleep. This period is, on an average, of about 35 minutes duration. Such periods, of course, recur during the cyclic alternation of sleep phases during the night, but, due to the uncertainty of locating them, hypnopaedic lessons are limited to the initial period mentioned above and also to another similar period occurring for about 20 minutes just before awakening.

Western (Evans & Orchard), Japanese (Tani & Yoshii), and Soviet (Maksimov & Zukharj) workers are unanimous in their findings on hypnopaedia. Their conclusions are:

1. Light sleep, when α wave can be easily provoked during lessons, is most suitable for hypnopaedia.
2. Repetitive presentation of the material to be taught is an essential pre-requisite.
3. No sleep learning is absorbed by the student if lessons are rendered during *D* and *E* stages when α wave activity is minimum or non-existent.

Hypnopaedic lessons should be short (about 3-6 minutes) and should be repeated several times during a session. For this purpose, either a special tape recorder with facilities for repetition or an endless-tape cassette running on a good tape recorder is necessary. The speaker should be very near the pillow of the subject and the recorder preferably out of the room. The lesson should start in a normal volume of voice gradually coming down to a whisper before going off. For the morning session, half-an-hour before the subject awakens, the lesson should start in a whisper ending in a normal volume. The best results can be obtained when the following requirements are fulfilled: (1) no background noise; (2) perfect audibility at low volumes; (3) clear utterence and slow speech with an even tone and tempo; (4) a firm but unemotional voice; and (5) impersonal nature of the lesson.

Hypnopaedic teaching experiments, mostly concerned with teaching foreign languages, have been carried out in many countries and the results are quite encouraging. To cite one example, an experimental course on basic English was carried out on a group of students in the dormitories of the Experimental Scientific Research Institute of Metal-cutting Machine Tools, Moscow. During the 105-day course consisting of 30 hypnopaedic sessions and an equal number of normal daytime revision classes, 1200 units of English language were taught. The students did not know a single word of the language before attending the course.

On completion of the course the students were examined by a board which reached the following conclusions:

"All the students could answer the questions correctly and could even ask logical questions and make short reports in English.

The students often corrected their mistakes without their teacher's help. They learned to carry on simple conversation in English and to read simple texts.

The successful results of the hypnopaedic course warrant the wider application of this method."

Even when hypnopaedia is scientifically acclaimed, some popular misconceptions about it exist. The most common of them are: (i) Hypnopaedia is some sort of brainwashing, (ii) The tape recorder mutters the lesson incessantly during the whole night, and (iii) Can something be learned by hypnopaedic lessons exclusively without the help of conventional teaching methods?

Hypnopaedia cannot be equated with brainwashing in any way. The latter in its wider sense of "indoctrination" attempts the removal of existing behaviour patterns and social, religious and cultural values of a person and their replacement by different ones by special psychological manipulations. The second misconception is already cleared. Regarding the third, it can be said that hypnopaedia in its present state of development cannot replace normal daytime learning and can only act as a supplement to the latter.

S.K. NAG

Cement and its constituents

THE cement used mostly in construction work is known as Portland cement. It is produced by heating lime-bearing material (mostly limestone) with materials containing silica, alumina and iron oxide (mainly clay). The first stage in producing cement is the careful mixing of the ingredients followed by heating them almost to melting point in various kinds of kiln under oxidising condition. The product, which is in a vitrified form is called clinker. It comes as hard, round nodules and is ground with about 4 per cent gypsum ($CaSO_4.2H_2O$) to produce a grey product —the Portland cement.

There are different types of Portland cement;

(1) *Normal or Standard portland cement* has average values for initial and final hardening when mixed with water. It is the most common form of cement.

(2) *White Portland cement* is used for facade (front side of a building) purposes. Its pale colour is due to the low percentage of iron oxide in its composition.

(3) *Hydrophobic* (*water-proof*) is normal Portland cement with small quantities of calcium stearate $Ca(C_{17}H_{35}COO)_2$ or small quantities of mineral oil added to it.

(4) *Low-heat Portland cement* contains a restricted percentage of aluminates. The heat given out by it during setting is much less than other grades.

(5) *Sulphate-resistant Portland cement* is resistant against attack by sulphates in water.

Joseph Aspdin, an English brick-layer, first took a patent on Portland cement in 1824 although the material was known earlier. He used hard limestone and clay as raw material. The limestone was calcined to produce lime (CaO) which was then mixed with clay. The mixture was ground to a slurry with water and then fed in a furnace similar to a lime-kiln.

The materials conventionally used for the manufacture of normal Portland cement (hereafter designated 'cement' only) in modern times are broadly same as those used by Aspdin, except for the improved process technology.

Modern manufacturing process of cement is divided into (i) wet method, and (ii) dry method. In the former case, the wet feed is introduced in the kiln while in the latter dry feed is used. The modern cement plant is automatic and the whole process of manufacture is optimized. The quality of the product is ensured with the help of on-line x-ray analysis, closed-circuit TV equipment, etc.

The chemical reactions between the various chemical species in the kiln take place in solid state in the presence of small amount of liquid. The ions such as Ca^{2+}, SiO_4^{4-}, etc, migrate or diffuse from their sites in the crystals to unite and form compounds which give the desired properties to Portland cement.

The chemical compounds that are essentially present in the clinker are tricalcium silicate (Ca_3SiO_5, alite), β-dicalcium silicate (β-Ca_2SiO_4, belite), tricalcium aluminate ($Ca_3Al_2O_6$) and tetracalcium alumino ferrite ($Ca_2Al_2Fe_2O_{10}$). These compounds contain many impurities in solid solution. For example, the chemical formula for belite is suggested as $Ca_{87}Mg\text{-}Al\,Fe(Na_{\frac{1}{2}}\,K_{\frac{1}{2}})(AlSi_{42}O_{180})$. In 1897 these compounds were first identified under polarizing microscope. The amount of these compounds in the clinker depends on the composition of the kiln-feed and temperature among other parameters.

Reaction with water

The reaction of cement with water is most important because the products formed out of such reaction give it the essential cementing properties. By measuring the heat evolved with time in this reaction, it is observed that the reaction takes place in stages as shown in Fig. 1. The initial setting extends approximately upto the stage III. The cement paste (cement and water) loses its plasticity and the final setting takes place at stage IV.

The reaction of cement with water leads to the formation of hydrates of the compounds with formation of calcium hydroxide. All the four compounds present in the cement react with water. Tricalcium aluminate, tricalcium silicate and tetracalcium alumino-ferrite react with water quickly while β-dicalcium silicate reacts slowly.

The ultimate product of reaction which gives the essential cementing properties is recognized as calcium silicate hydrate (C-S-H) compounds. Its formula is given as $CaO_{0.8\ 1.5}SiO_2.H_2O_x$ and is similar to mineral 'tobermorite'.

The reaction slows down after five minutes because of the formation of intermediate compounds (known as sulpho-aluminates) which coat the cement grains temporarily preventing access of water to unreacted cement particles. The addition of gypsum thus serves the purpose of formation of intermediate sulpho-aluminate compounds which, in turn, check quick setting or the so-called false setting of cement. There are, however, certain advantages of the presence of aluminate and ferrite. They form hydrates in the early stage of reaction with water. Besides, the presence of alumina and iron oxide in the raw meal act as a flux to lower the temperature for clinker formation.

Tricalcium aluminate and tetracalcium ferrate hydrates are responsible for the early strength of cement-based products, e.g., mortar (cement, sand and water), concrete (cement, sand, crushed stone and water), etc. Tricalcium silicate contributes to the major strength at early stage of reaction with water while β-dicalcium silicate does so at a later stage. The products obtained by

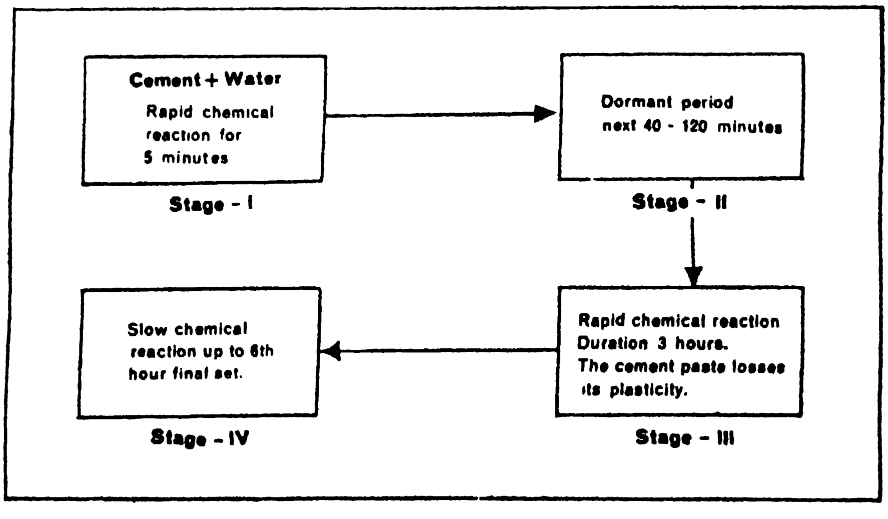

Cement + Water
Rapid chemical reaction for 5 minutes
Stage - I
Dormant period next 40 - 120 minutes
Stage - II
Rapid chemical reaction Duration 3 hours. The cement paste losses its plasticity.
Stage - III
Slow chemical reaction up to 6th hour final set.
Stage - IV

Fig. 1. Reaction of cement with water

the reaction with water of the above two calcium silicate compounds are more or less the same except that the specific surface of the C-S-H gel produced by tricalcium silicate is somewhat more strong than that produced by β-dicalcium silicate. The high reactivity of tricalcium silicate is assigned to the defects (holes) in its crystal structure.

It is evident that the C-S-H gel is chiefly responsible for cementing properties of Portland cement. The gel has tremendous surface area of the order of 2-3 × 10^6 cm^2/gm. Finely-ground quartz (SiO_2) of specific surface area 20,000 cm^2/gm is known to have considerable compressive strength. Thus, it can be assumed that surface forces (Van der Waals type) are responsible at least to some extent for the cementing properties. However, certain other chemical forces, e.g., hydrogen and valence bondings, are suggested to be operating in the C-S-H gel. The poor tensile strength of cement products is ascribed to Van der Waals type bonding while comparatively high compressive strength of cement products to valence type bonding. However, no clear picture of the bonding nature of the C-S-H gel is available at present.

S.N. Ghosh

Glycoproteins

GLYCOPROTEINS are defined as proteins in which carbohydrates are covalently bound to polypeptide chains. These compounds are widely distributed in animal tissues, plants and micro-organisms. The carbohydrate content may vary from less than one per cent to more than 80 per cent of the weight of the glycoproteins. The various sugars isolated from different glycoproteins have been indentified as D-galactose, D-mannose, L-fucose, D-xylose, N-acetyl-D-glucosamine, N-acetyl-D-galactosamine and various derivatives of neuraminic acid (Fig. 1). A glycoprotein molecule may contain one to seven different sugars. The number of carbohydrate units in differernt glycoproteins is also variable. There may be only a single carbohydrate unit per molecule, e.g., in ribonuclease B, ovalbumin or deoxyribonuclease, or there may be as many as 800 units, e.g., in ovine submaxilary glycoprotein. Glycoprotein molecules also vary in molecular weight from 14,500 for ribonuclease to 1,000,000 for the ovine submaxillary glycoprotein. The spacing of carbohydrate units along the peptide chain is also variable, e.g., in immunoglobulin IgG, it is after every 779 amino acid residues, whereas in ovine submaxillary glycoprotein it occurs after every 6 amino acid residues. A segment of the polypeptide chain containing acids with a high density of carbohydrate units (mucin) and one with a low density (plasma protein) is shown diagrammatically in Fig. 2.

The carbohydrate units of glycoproteins from mucous secretion and those with blood-group activity may contain galactose, N-acetylglucosamine, N-acetylgalactosamine, sialic acid and fucose. Very simple carbohydrate units occur in some glycoproteins such as N-acetylneuramine disaccharide found in ovine submaxillary mucin and the glucose-galactose disaccharide unit found in basement membranes. Some of the glycoproteins contain carbohydrate units made up of a single residue linked directly to the peptide chain, such as galactose in collagen and N-acetylgalactosamine in glycoprotein from mucous secretion.

The covalent bonding of carbohydrate moiety of glycoproteins has been shown to involve carbon-1 of the most internal sugar residue and the functional group on an amino acid in the peptide chain. Three distinct types of glycopeptide bonds have been shown to occur in proteins from animal tissues (Fig. 3). The first glycopeptide bond can be formed by carbon-1 of N-acetylglucosamine and amide nitrogen of asparagine. This type of linkage occurs in ovalbumin, ribonuclease, deoxy-ribonuclease, fetuin and thyroglobulin. Another glycopeptide linkage involves an O-glycosidic bond to an amino acid serine or threonine. The sugar component of this type of linkage is N-acetylgalactosamine or xylose. This type of linkage is involved in various mucin and glycoproteins with blood-group activity. The third type of glycopeptide linkage was recently discovered in basement membranes and collagens. It involves an O-glycosidic linkage between a galactose and the hydroxyl group of hydroxylysine.

With the exception of IgA and glomerular basement membrane, which have two types of carbohydrate-peptide bond, all the glycoproteins contain only one type of carbohydrate-peptide linkage.

Functions of glycoproteins

Glycoproteins take part in enzymic and hormonal activities; antigen-anti-body interaction; metal and hormone transport; binding phenomena and the blood clotting mechanism. They act as filtration barriers, supportive structures and as the components of various cellular membranes.

The role of the carbohydrate part in glycoprotein is not known in most cases. A correlation of the

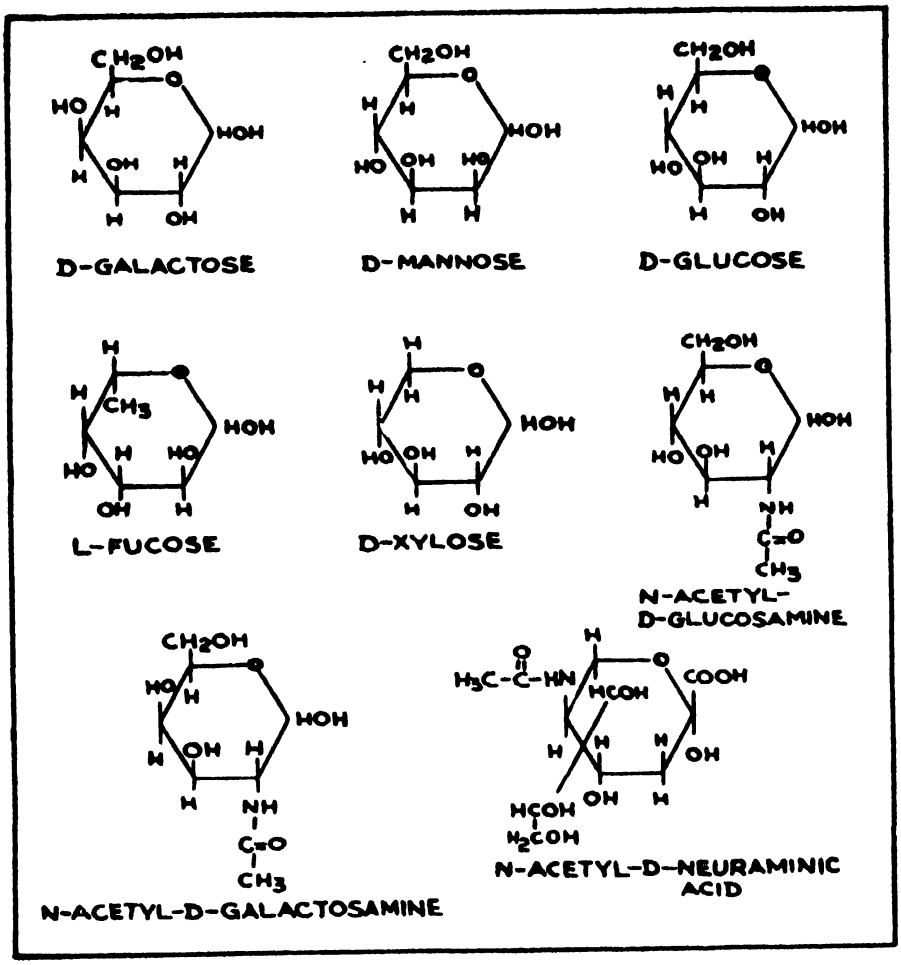


Fig. 1

carbohydrate moieties with their biological functions has been made for some proteins. The hormonal activity of chorionic gonadotrophin and follicle stimulating hormones is lost with the loss of terminal sialic acid residue of the carbohydrate unit. Whereas the transport function of plasma glycoproteins such as haptoglobin, transferrin, thyroxine-binding globulin, and the corticosteriod-binding globulin is not eflected by the removal of sialic acid from carbohydrate moiety. The conversion of fibrinogen to fibrin, associated with clotting of blood, is accompanied by the release of a carbohydiate from glycoprotein fibrinogen. The viscosity and lubricating quality of mucous secretions is due to the presence of glycoproteins.

Glycoproteins contain large numbers of short-chain oligosaccharides. The polar character of the carbohydrate attracts water, so there is little hydrophobic interaction between the large surfaces. The many negative charges carried by the terminal N-acetylneuraminly residues repel each other, serving to keep the molecule extended and overcoming any tendency for them to stack up. The sheath of water and their tendency to keep apart enable them to lubricate.

Fate of gluco proteins

The lysosomes present in tissues contain hydrolytic enzymes which degrade a large number of macromolecules including proteins, nucleic acids, lipids and carbohydrate polymers. A group of glycosidases occur in these lysosomes. Among them are β-galactosidase, α-N-acetylgalactosaminidase, β-N-acetylglucosaminidase, α-mannosidase, neuraminidase and α-fucosidase. These lysosomal glycosidases hydrolyse the carbohydrate from the glycoprotein and the proteases help in de-

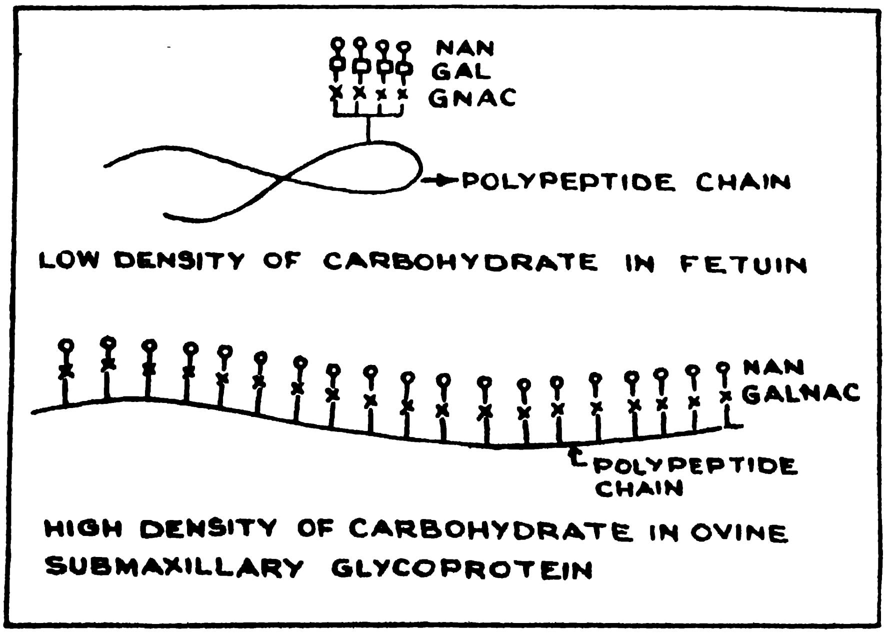

NAN
GAL
GNAC
POLYPEPTIDE CHAIN
LOW DENSITY OF CARBOHYDRATE IN FETUIN
NAN
GALNAC
POLYPEPTIDE CHAIN
HIGH DENSITY OF CARBOHYDRATE IN OVINE SUBMAXILLARY GLYCOPROTEIN

Fig. 2

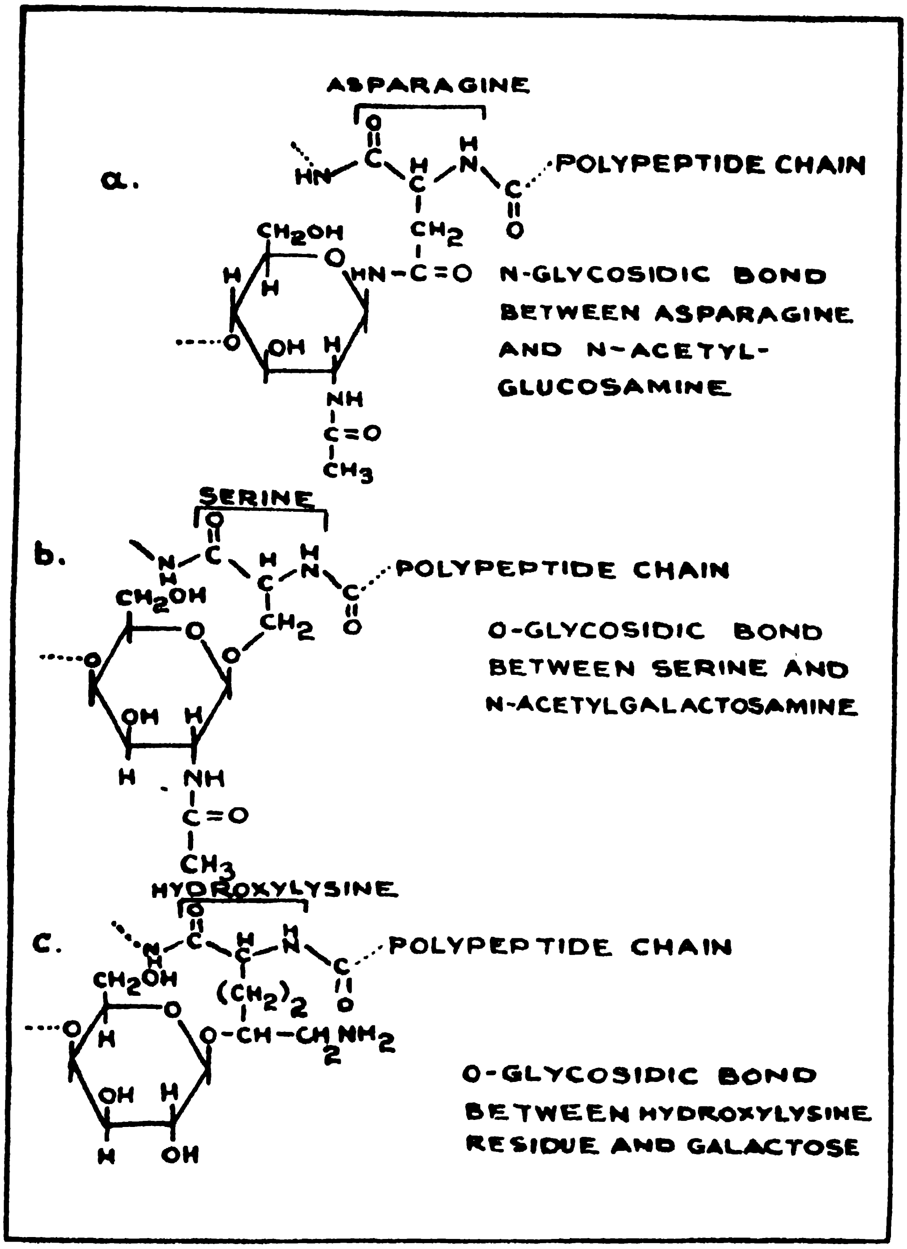

ASPARAGINE
a.
POLYPEPTIDE CHAIN
N-GLYCOSIDIC BOND BETWEEN ASPARAGINE AND N-ACETYL-GLUCOSAMINE
SERINE
b.
POLYPEPTIDE CHAIN
O-GLYCOSIDIC BOND BETWEEN SERINE AND N-ACETYLGALACTOSAMINE
HYDROXYLYSINE
c.
POLYPEPTIDE CHAIN
O-GLYCOSIDIC BOND BETWEEN HYDROXYLYSINE RESIDUE AND GALACTOSE

Fig. 3

gradation of rest of the molecule. Lysosomes from kidney and liver, for example, can degrade in a stepwise manner the sialic acid-galactose-N-acetylglucosamine chain of fetuin carbohydrate unit. Lysosomes can degrade the ovine submaxillary mucin by splitting off both the N-acetylneuraminic acid and the acetylgalactosamine of the disaccharide units attached to this protein at regular intervals.

Disorders of degradation

A number of pathological conditions are known in which the degradation of macromolecules containing carbohydrate, whether glycoproteins or glycolipids, appears to have been disturbed. Glycoproteins accumulate in generalized gangliosidosis, a rare inborn error of carbohydrate metabolism, due to pronounced decrease in the lysosomal β-galactosidase in liver and brain of the patient. Hurler's syndrome is a disease characterized by the accumulation and increased urinary excretion of dermatan sulphate and heparin sulphate in addition to excessive cerebral storage of gangliosides. The site of intracellular storage of the proteoglycans (mucopolysaccharide-protein complex) has been localised in vacuoles which have the ultra-structure and histochemical characteristics of lysosome. The proteoglycans that accumulate in Hurler's syndrome have smaller peptide portion and their carbohydrate moiety than in their normal analog, which suggests that incomplete degradation of these polymers take place. This has been shown due to low activity of β-galactosidases in the tissues of patients with Hurler's syndrome.

Gaucher's and Fabry's diseases have been regarded primarily as storage disease in which glycolipids and proteoglycans degradation is impaired.

Another disorder representing defective degradation of glycoprotein is aspartylglycosaminuria, a disease in which large amount of N-acetylglucosaminyl asparagine is excreted in the urine. The excess of this excreted compound has been shown to be of endogenous origin and an absence of β-aspartylglucosylamine amidohydrolase has been reported to occur.

B.L. Kwatra

NEWS & NOTES

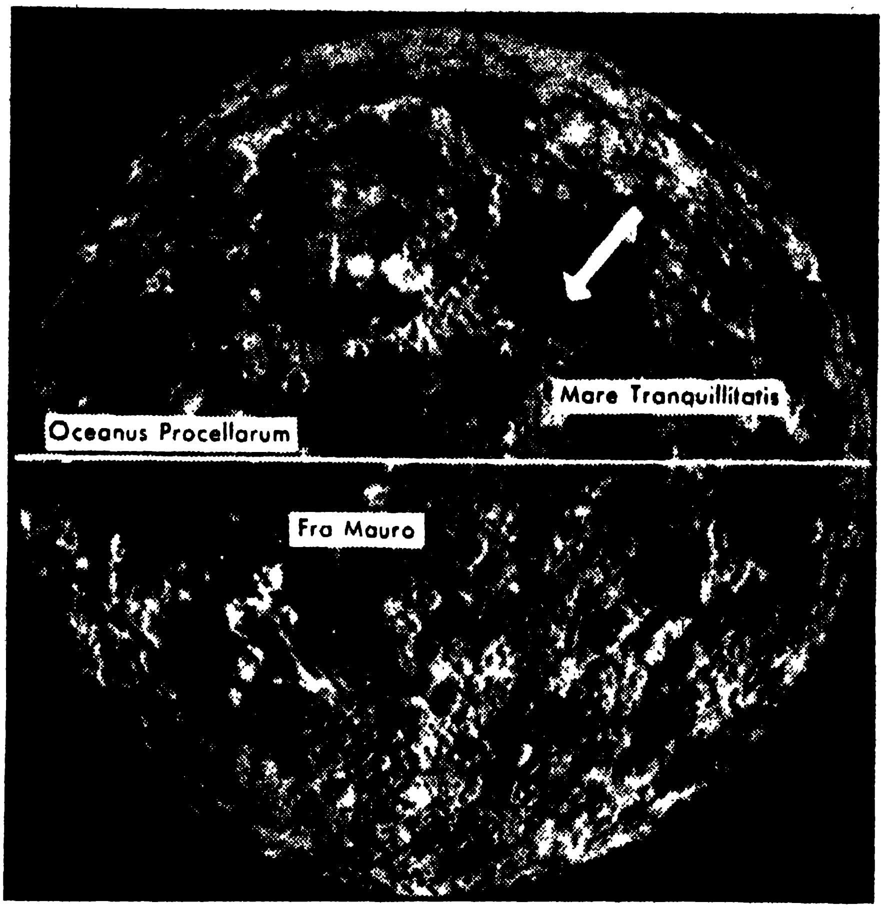
Virologist Karl Meyer dead

DR. KARL F. MEYER, an internationally renowned veterinarian and viral researcher whose scientific works touched on virtually all fields of medicine, died of cancer in San Fransisco on April 27 at the age of 89 years. He was regarded as the most versatile microbe hunter since Louis Pasteur and a giant in public health research.

Born in Basel, Switzerland in 1884 young Meyer was educated as a veterinarian at the University of Zurich. By the age of 25, he gained international acclaim by his work in South Africa where he devised the means for the protection of cattle against East Coast fever, a deadly tick-borne infection. In 1910, he immigrated to the U.S.A. and joined the University of Pennsylvania. In Philadelphia, his research linked Bang's disease of cattle and a human disease just then reported from Malta (brucellosis after its discoverer Dr. David Bruce). In 1914, in Philadelphia, Dr. Meyer isolated the eastern equine encephalitis virus and developed a vaccine against it. He worked with typhoid epidemics and his findings emphasized the importance of the human carrier as the major source of this disease. In the thirties, when the Philippine farm workers were struck by a mysterious disease, Dr. Meyer linked it to a fungus called coccidiodes in the soil, the disease now being known as coccidimycosis. When California's aviaries were struck with parrot fever, he isolated the virus, showed that the infection affected all birds, and helped develop control measures that had a major impact on the turkey industry. He found that leptospirosis was an infection spread not only by rodents but also by infected dogs, cattle and other animals. He traced one types of cattle illness in California to lead poisoning. Dr. Meyer's control measures rescued the canning industry from botulism epidemics, a deadly form of food poisoning that threatened commercial canning in its infancy.

In 1916 Dr. Meyer became

Moon crater named after Sarabhai



A crater in the Sea of Serenity on the moon has been named after the late Dr. Vikram A. Sarabhai, who launched India's space proprogram. The International Astronomical Union (IAU) at a recent meeting has decided to rename craters after eminent scientists, writers, painters and composers who made significant contribution to the growth for human culture and knowledge.

Sarabhai is the name adopted for the crater 'Bessel-A' (shown by arrow in the picture) situated at 21° longitude and 24.7 latitude in the Sea of Serenity.

Director of Hooper Foundation at the University of California in San Francisco. This position he held until 1954 when he reached the mandetory retirement age. But he continued his life-long research on plague and other diseases. He published more than 800 papers and was elected President of the Society of American Bacteriology (1935).

R.K. Datta

CSIR scheme for entrepreneurs

CSIR scientists, technologists and engineers, individually or in association with others, can now set up industries based on CSIR know-how for commercial utilisation and for exploitation of researches carried out by the CSIR for industrial development. The purpose of this scheme is to create cadre of entrepreneurs to experiment with new ideas and methods of organisation and to facilitate transfer of technology. Under this scheme a scientist/technologist/engineer would be free to choose either a process developed by him or any other process of CSIR Laboratory/Institute that he may like to take up for production. He can avail of the facility of use of pilot plant and other equipment, etc., against suitable charges. CSIR will grant extraordinary leave for a period of three years to such scientists. On expiry of the leave, he will have to either join back the service of the CSIR or resign his post, or seek voluntary retirement as permissible under the rules.

Prof. Blackett passes away

As the current issue of *Science Reporter* was in press, we received the news of the sudden passing away on July 13, in London, of Prof. P. M. S Blackett, the eminent nuclear physicist and Nobel Prize winner He was 76.

Born on 18 November, 1897, Patrick Maynard Stuart Blackett had his education at Cambridge University under the great physicist Sir Earnest Rutherford. In his early teens he served with the Royal Navy during World War I. In 1932, before he was 30, he achieved international reputation by discovering the existence of the positron (along with Anderson and Occilianini). He was awarded the Royal Society Medal in 1940 for the study of cosmic rays and his work on mesons. During World War II, he worked on the development of the atomic bomb and radar.

Prof. Blackett was awarded the Nobel Prize for physics in 1948 for his discoveries concerning cosmic radiation and development of the Wilson cloud chamber method for the study of swift atomic particles in cosmic rays. In 1956, his studies of cosmic ray showers and heavy mesons and his contributions in the field of palaeomagnetism brought him the Royal Society's coveted Copley Medal.

A brilliant academician and researcher, Blackett was elected a Fellow of the Royal Society of London in 1933. He served as its president from 1965 to 1970. He was also president of the British Association for the Advancement of Science during 1957-58.

A personal friend of the late Shri Jawaharlal Nehru, Blackett visited India several times and was one of the chief architects of the country's science policy. Delhi University awarded him the honorary Doctor of Science in 1947. Two years later he was made an Hon. Fellow of the Indian Academy of Sciences.

An authority on science policy, Prof. Blackett was member of the scientific policy committee of the European Organisation for Nuclear Research (1954-58), governing board of the National Institute for Research in Nuclear Science (1957-60), Council of the Institute for Strategic Studies (1958-60), Board of Trustees, British Museum (1963-64), and Council of the Royal Institute of International Affairs (1956-60). From 1965 to 1969 he was the deputy chairman of the advisory council of UK's Ministry of Technology.

Besides his work on nuclear science, Prof. Blackett also wrote various books on military studies which provide a glimpse of his views on the political significance of nuclear power. Notable among them are *Military and Political Consequences of Atomic Energy* (1948), *Atomic Weapons and East-West, and Studies of War* (1962).

MEDICAL NOTES

Radiation sterilisation of medical products

IN the medical field, it is often essential to sterilize equipment, devices, pharmaceuticals and bio-products to prevent secondary infections in patients. The ultimate purpose of any method of sterilization is the destruction of micro-organisms; in accomplishing this, however, the article being treated should not be deformed or defaced.

There are four conventional methods of sterilization, viz., steam, dry-heat, gas, and filtration. Each of these techniques is used for a particular material. Thus sterilization by steam is particularly suitable for solutions contained in glass vials and for routine hospital requirements; dry heat for materials resistant upto 170° C, gas for materials sensitive to heat but chemically stable to ethylene and propylene oxides and filtration for solutions which are particularly sensitive to heat.

Radio-sterilization, i.e., sterilization by ionsing radiations, has been found useful in many instances where other conventional procedures are inapplicable. The fact that radiation can be used in sterilizing medical products and devices in their final sealed packages, or even in shipping cartons, is a major direct advantage to the pharmaceutical industry. With proper packaging, the sterility is assured for an indefinite period, and ready-to-use sterile products can be made available for emergency situations and for routine medical practice.

The other main advantage of the radiation process is that it can be controlled more easily and requires essentially the control of one parameter, namely, process time, all the other parameters being fixed at the design stage. The conventional processes involve the control of a large number of parameters like temperature, pressure, time, concentration, humidity and nature of the primary wrapping. Sterilization by radiation has a special advantage in sterilizing biomedical products generally.

The product which is to be sterilied is packed in standard corrugated cardboard boxes and is kept on carriers, each having five shelves, which take them with a controlled speed to the irradiation cell. Every container passes each side of the source five times and returns through the exit. To sterilize the product, a minimum dose of 2.5 million rads is given.

About 20 radiation sterilization plants are at present in operation throughout the world. In the United States of America, sterilization is being done by cobalt-60. The products sterilized include starch glove lubricating cream; disposal hypodermic needles and syringes, plastic intravenous catheters, plastic disposal gloves, surgical dressings, bandages, gauze, eye pads, etc.

In the United Kingdom, the technique of the radio-sterilization is now well established on an industrial scale. There are obout 5 plants using gamma radiation from the radioisotope ccbalt-60 and one using electron machine. The products which are sterilized include sutures, plastic hypodermic syringes, hypodermic needles, plastic and rubber catheters, plastic examination gloves, cannaule, dialysis units, infusion sets, arterial prostheses, indotracheal tubes, acrylic powder, petridishes, surgical blades, blood lacets, various plastic bags and containers for certain pharmaceutical preparations and pathological samples, etc.

Radiation sterilization in France is done by two units, one of which employees a 137-Cs sources.

In Denmark radiation sterilization is done by linear accelerators. Other countries such as Czechoslovak Socialist Republic, Federal Republic of Germany, Hungary, Italy, Sweden and Switzerland are also planning for radiation sterilization of medical products.

One of the major programmes of atomic energy in India is the promotion of radiation sterilization as a modern industrial process. The potentialities of this technology have been very well visualised by the medical profession and manufacturers of medical products. In view of the urgent need for introducing this technology in India, a proposal for a radiation plant for sterilization of medical products was initiated by the Department of Atomic Energy (DAE) and assistance sought from the United Nations. Now, this plant, known as ISOMED, which is the first large-scale plant for radiation sterilization of medical products in Asia, has been commissioned at the Bhabha Atomic Research Centre, Trombay. The project is jointly financed and promoted by the United Nations Development Programme (UNDP) and the Government of India. The International Atomic Energy Agency (IAEA), on behalf of UNDA and DEA, executed the project.

The project building covers an area of approximately 1,500 sq. meters. The plant consists mainly of (i) The radiation source housed in a concrete cell, (ii) an automatic system for conveying the product boxes into the irradiation cell, exposing them to the radiation field for a specific period and taking them out of the cell, and (iii) service laboratories for microbiology, dosimetry, etc.

Apart from the regular irradiation services, ISOMED will offer several other auxiliary services in areas relating to radiation sterilization of medical products. These include packagng, microbiology, study of physicochemical effects of radiation on various medical and pharmaceutical products, product development, etc.

It is hoped that ISOMED will serve as a centre for training scientists, engineers and technicians from developing countries in all aspects of radiation sterilization. In the words of Dr Sethna, "We are aware that the potential for radiation sterlization in this country cannot be fully satisfied solely by ISOMED located at Bombay. The Department of Atomic Energy is therefore planning to set up more plants in order to give adequate coverage to each of the major zones in the country."

S.K. KUMRA
M. K. RAGHAVENDRA RAO

Cancer and life-style

THE Kalinga Prize winner and editor of *Science*, Philip H. Abelson has made a case for simpler life, to avoid the on, laught of cancers, (*Science*, 182, 7 Dec. 1973). In the U.S.A. alone each year more than 6,65,000 new cases of cancer and about 3,80,000 deaths caused by it are reported. The direct medical expenses involved are estimated at $ 3 billion. The agony of patients and the heartache of families and friends represent a far more serious cost.

Since cancer is a highly dreaded disease, many physicians and scientists have devoted their lives fighting it. However, most of them have been only moderately successful. Cancer is not one disease, it is a hundred or more types. A few of them respond well to intervention—surgery, radiotherapy, or chemotherapy. But overall, the probability of achieving a 5-year cure is only about 40 per cent. In some instances, such as those of brain or lung cancer, the possibility of a cure is poor. For many kinds of cancer, there just does not seem to be even a dim possibility of a cure in many years to come. Therefore, the most practical approach will be to find means of prevention.

Experts in epidemiology have estimated that 80-90 per cent of cancerous tumours may be related to environmental factors. Some of the causative agents are obvious and produce clear-cut effects. For example, about 30 per cent of cancer deaths of man in the U.S.A. are attributed to cigarette smoking. In other instances the causative agents are not known with definiteness, but there are tantalizing indications of some 27 per cent of the cancer deaths being connected with diseases of the digestive organs. The Japanese suffer nearly seven times as many deaths from stomach cancer as the Americans do. However, Japanese deathrate from cancer of colon and rectum is less than half that of Americans. Various studies show that these differences are largely dietary in origin —and that those Japanese citizens who have changed their customs after emigration approached the cancer incidence of their new neighbours.

Interestingly, Roland L. Phillips of Lona Linda, has established that devout Seventh Day Adventists in California experience an overall cancer incidence only a third that of other citizens of California. He atttributes it to their life-style. May be, a simpler life-style, with diets that are unfried or only feebly-fried, and contain lesser chillies and other tasteries, can help prevent the development at least some types of cancer, if not all.

MANGAL NATH

SPERM PRODUCTION (*Continued from page 342*)

testicular biopsy, has proved quite fruitful in the screening of parenteral and oral antispermatogenic agents.

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SCIENCE FOR THE YOUNG

Corals—the tiny architects of the sea

NOWHERE on earth does life exhibit a greater diversity of colour and shape than in the coral reefs. They are the cities of the under-water world—crowded, bustling communities populated by creatures belonging to nearly every major group in the animal kingdom. The coral reef, with its great variety of structures and colours, may be considered the most spectacular of nature's wonders, yet it is built by tiny animals.

The most interesting oceanic islands are those built up by corals and certain other microorganisms. It is estimated that the world's coral reefs of all types have a combined area of approximately 1.5 million square kilometers.

The surface of dried, bleached coral skeleton is riddled with tiny, cup-shaped pits. These pits were the homes of the individual coral animals or polyps. These stony corals are the chief architects of the reefs.

A coral colony consists of thousands of polyps, all arising from a single individual. The fertilized eggs of reef-building corals grow into free-swimming, pear-shaped larvae. A larva settles on to a solid surface with its broad mouth upwards, and cements its narrow base in place, often on the remains of its ancestors. It secretes a lime-stone cup around itself, and spends the rest of its life in this external skeleton. The soft part of the animal within the skeleton seldom reaches more than 8 mm in size.

The polyp sends out little branch-like buds, and these grow into other polyps that remain attached to the parent. As time goes on, each new polyp develops buds in turn, and a closely-knit community of coral develops. In colour, it may be brown, lavender, yellow, green, voilet or pink. The colony grows upwards and outwards assuming a variety of coral shapes—staghorn, elkhorns, brain, finger, flower, star and cactus (Fig. 1).

The sea supplies them with their building material—carbonate of lime. The polyps extract this partly from their food and partly from the sea. With this supply of carbonate of lime they make tiny platforms between themselves and the rock upon which they stand. The platforms grow thicker and thicker as polyps add layer after layer to form their own tiny, stony pedestal. Competition is keen as each polyp struggles to build higher than his neighbour, and thereby to reach a more abundant supply of floating food.

Coral animals do not dwell alone in their stony apartments. Microscopic plants called dinoflagellates also live within their body tissues. The corals form reefs only when they harbour dinoflagellates. The relationship between the polyps and their plant tenants appears to be beneficial to both. Coral animals offer their plant guests a sheltered environment rich in carbon dioxide. This gas, given off as a waste product by coral, is one of the raw materials for the dinoflagellates to manufacture their food. Reef-building corals grow only in warm, clear water, less than 50 metres deep, where there is enough light for their plant partners to carry on photosynthesis.

There are three kinds of coral reefs—fringing reefs extend directly out from the shore; barrier reefs are parallel to the shore but are separated from the land by deep water; and atolls are circular reefs which grow in the open sea. It is the labour of untold generations of small workers that has reared up the coral islands, reefs and atolls of the oceans as we know them today. Coral islands have been called "Oases in a watery desert"—the desert of the open ocean.

The Great Barrier Reef extends for nearly 2100 km along the north-eastern coast of Australia. It could supply enough limestone to build some eight million replicas of Egypt's largest pyramid. Much of its enormous length has remained the undisturbed property of its master builders, the corals, and its varied population of other sea animals. Long stretches of its sandy shore have not been touched by humans. Some five hundred of the reef's cays (low islets) and islands are still unopulated.

By day and night, while the coral polyps are building up their dwellings in many patterns, other forces are at work, tearing them down. The Trade Winds are forever hurling waves against the seaward coral walls. Tropical down-

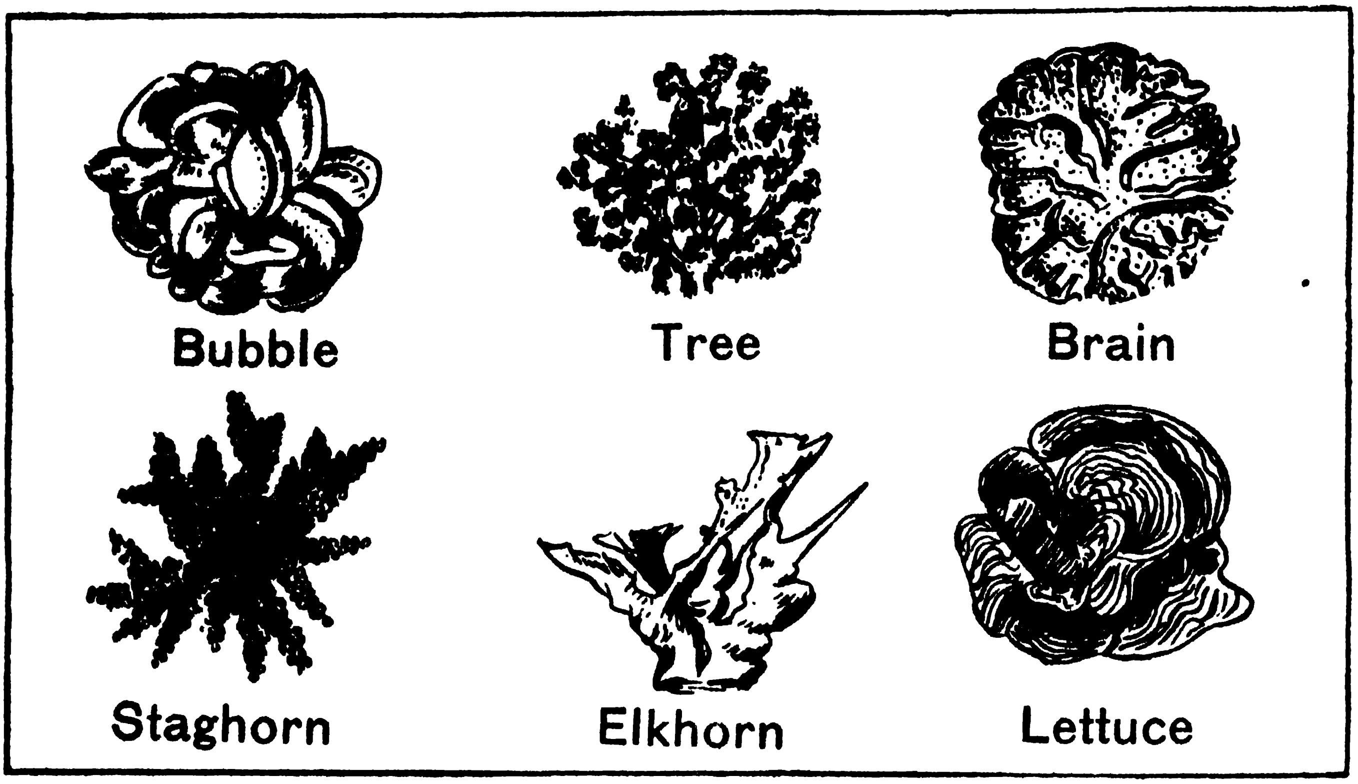

Fig. 1. Various coral forms

pours of rain reduce the saltiness of the water and often turn a whole busy community of coral into a graveyard. There are plant and animal enemies too — sea urchins that rasp holes into the coral walls, molluscs and algae that bore in, clams that wedge themselves into cracks, deepening them into cavities. As everywhere in Nature, destruction goes on side by side with growth, and death with life.

In the 1960's, a very dangerous reef wrecker, a starfish, appeared in alarming numbers on Pacific reefs. The 'Crown-of-thorns' starfish, which gets its name from the bristling spines with which it discourages predators, eats the living coral heads of a reef. When the living coral is killed the reef is open to erosion and eventual destruction by the ever-pounding ocean waves.

As the older coral colony inhabitants die and leave their cells empty, new generations add more layers to the stony edifices slowly forming in the sea. In due course a huge structure is raised above sea level and another reef appears. However, this does not happen in a few years or even centuries. Ages have passed, for instance, in the making of the Great Barrier Reef of Australia.

G. CHAKO

Plastics—a gift from science

PLASTICS are a class of man-made non-metallic synthetic products that consist of organic substances made up of large and complex molecules. The raw materials are crude oil, natural gas, coal, cotton and organic compounds. Plastics vary widely in their properties. The thermosetting plastics like bakellite will stand high temperatures, are resistant to chemicals, are hard to break or burn, and are not easily scratched. In contrast to these, the thermoplastics like nylon, polyvinyl chloride (PVC) soften at moderately high temperatures, are more readily attacked by chemicals, and burn easily. Because plastics may be produced having properties anywhere between these two extremes, they are useful for the manufacture of many industrial and domestic commodities. Most of the thermoplastics are produced by polymerisation whereas the thermosets are polycondensation products.

The plastic products are produced by moulding or casting. There are three basic moulding processes, namely, injection moulding, compression moulding, and vacuum moulding. In injection moulding, the granular or powder plastic is fed into a cylinder where it becomes liquid on heating. It is then forced under pressure through the nozzle into the mould. It fills the cavities of the mould and hardens soon after cooling. In the compression moulding, the mould is filled with thermosetting plastic and the two parts of the mould are pressed together with the combination of heat and pressure. On cooling the permanent shape is attained. In the vacuum forming, the hot plastic sheet is clamped on the moulds and vacuum is created between them. The atmospheric air pressure forces the plastic into the mould which hardens after cooling. In casting, the mould takes the shape of the product and the liquid plastic is poured into it. Dyes and pigments may be added to the plastic to get the desired colours. The fillers are added to increase the bulk without altering the properties.

To impart toughness and flexibility certain low-melting subsances are added. These additives, called plasticizers, are merely physical additions. Such substances as phthalic acid esters, phosphate esters, castor oil or sulphonamides are generally used.

The plastics are resistant to moisture, corrosion and chemicals. They are light and easily deformable. They have low heat and electrical conductivity. Acrylic plastics such as Perspex are clear, transparent and weather-resistant. They are used for airplane wind-shields and medical instruments. Alkyl plastics are used for the manufacture of car ignition parts and radio tube bases. Nylon (polyamide plastic) has high luster and tensile strength (4 times that of steel). It is used for tyre treading, knitted wears, marine ropes, parachutes and surgical apparatus. Bakelite (phenol formaldehyde) is tough and strong and is used in the manufacture of electrical plugs, sockets, etc. The thermoplastic celluloid is used for the manufacture of buttons.

Certain plastic materials can be expanded by foaming method to produce either rigid or flexible forms. The rigid forms are used as core material for laminates, low density fillers, thermal and acoustic insulators. Plastic pipes and tubes are made out of polythene and PVC. The best known plastic is polythene which is flexible, light, tough, unbreakable, water and chemical proof. The polythene products such as bowls, buckets, wrappers, light fittings, toys, upholstery, insulation and fabrics are available in a variety of colours.

In fibre-reinforced plastics the usual reinforcing material is glass fibre. The glass filament or glass mat is normally laid in helix fashion and impregnated with hot-setting epoxy resins. The strength of fibreglass plastic is better than steel and depends upon the wall thickness and laminate material. It has dimensional stability, weather resistance, stability under extreme temperature and humidity, and low water absorption.

Garments made out of new type of synthetic acrylic fibres are noninflammable. They are light in weight and warmer than wool and free from fetting or shrinking. As a summer wear, they produce a kind of air conditioning by capillary action.

SATISH K. PURI

SCIENCE IN INDUSTRY

Water filter candles

WATER available from sources like river, pond and lake contains a number of undesirable impurities. Its pretreatment for the removal of suspended impurities and bacteria has, therefore, become a practical necessity in all water-supplying agencies. The nature of the treatment given to raw water varies from place to place and depends upon the conditions of water. Various processes are available for the treatment of water for making it suitable for drinking purposes. The general procedure consists of storage, aeration, sedimentation, coagulation, rapid and slow sand filtration and chlorination. In spite of these treatments, the municipal water supplies in many towns are not completely safe to drink. Raw water contains harmful bacteria capable of causing water-borne diseases such as cholera and typhoid. These bacteria have to be removed to make the water potable. If an efficient water treatment procedure is not available, it is advisable to process water in every house before using for drinking purposes. One of the common methods of treatment of water for household purposes is to ilter it through beds of sand, gravel and charcoal to remove suspended mpurities, followed by boiling to kill the harmful bacteria. Though efficient, this process is costly and time consuming. The use of water filter candles comes handy for this purpose, and is therefore becoming increasingly popular. Two types of water filter candles are available in the market. One gives bacteria-free water (Sterasyl type), and the other gives water free from suspended impurities only. Such filter candles are not manufactured in the country in quantities sufficient to meet the demand; bulk of it has to be imported. The total annual consumption of these candles in the country is estimated at more than a lakh of pieces valued at about Rs. 15 to 20 lakh. The market price of such candles ranges from Rs. 25 to Rs. 90 per piece. The life of these candles is reported to be 2-3 years for filtering the average quality water.

The Central Glass and Ceramic Research Institute (CGCRI), Calcutta has carried out investigations on the production of Sterasyl type candles using indigenously available ceramic materials and has succeeded in developing a process for the manufacture of such candles without the use of kieselguhr, which is commonly used for the manufacture of the filter element but is not available in the country in commercial quantities. The process consists in grinding non-plastic materials like quartz and felspar to required fineness and mixing with China clay and some other organic combustible materials. The casting slip is prepared by the addition of electrolytes. The candles are first moulded by casting, using plaster of Paris moulds of desired shapes. These can also be made by extrusion through pug mills. These are then turned and finished to required dimensions and baked at a suitable temperature in an electrical or oil-fired kiln. Candles are then tested for flaws and then given a special chemical treatment followed by a second baking to make them suitable for filtering bacteria-free water. These are then fitted with caps and checked for leakage through the caps. Chemically treated and cap assembled candles, tested by four pathological laboratories for bacteria filtration tests, have been found satisfactory.

Katadyn pocket filter pumps used by Defence Services for supply of potable water in remote areas have also been developed at the Institute. Raw water is pumped through these pocket pumps and bacteria-free potable water, also free of suspended impurities, is obtained. The pocket size pump is fitted with a ceramic tube open at both ends. Water passes from the water jacket to the inside of the tube through the porous ceramic tube and gets filtered. The ceramic tube normally lasts three months, after which it has to be replaced. The annual requirement of such tubes by the Defence is 21,000 pieces, involving foreign exchange amounting to Rs. 14 lakh. The Institute has successfully developed such tubes and these have been tested by the Defence Science Laboratory. Tests were carried out using *Esch. coli* organisms, which are even smaller than typhoid, dysentery and cholera bacilli.

The major raw materials required for the manufacture of these candles are: refractories, clays, quartz felspar, plaster of paris, cement chemicals and organic combustibles. All these are available indigenously.

The main item of plant and machinery like edge runner, ball mill,

blunger, electromagnet, furnaces, compressors and dryer are all indigenously available and can be fabricated by local machinery manufacturers.

The total capital outlay for a plant capable of producing 1,000 candles per day is estimated at Rs. 6.46 lakh (Rs. 3.34 lakh towards plant and machinery and Rs. 3.12 lakh as working capital). The cost of production of the candles comes to Rs. 3.30 per piece as against Rs. 25 to Rs. 90 quoted in market for imported candles.

Low temperature red clay glazes

THE Central Glass and Ceramic Research Institute (CGCRI), Calcutta, took up investigations on the development of suitable glazes substituting the imported tin oxide and minimizing the use of lead oxide at the instance of the Regional Design Centre (Calcutta) of the All India Handicrafts Board which supplies readymade ceramic glazes to village potters. The glazes so far used contained high amounts of tin oxide and red lead. Tin oxide is an imported material and is very expensive. Red lead is prepared from imported lead metal which, apart from being very expensive, is injurious to human health. Earlier investigations carried out at the Institute resulted in complete substitution of tin oxide by indigenous zircon opacifier, which was developed using processed zircon sand from the Kerala Beach sand. The substitution of tin oxide reduced the cost of the glazes by about 75% and consequently resulted in four-fold increase in the consumption of such glazes.

The red lead content, which originally ranged between 20 and 50% **was brought down to 10-12%. Even this quantity was added in the form of insoluable frit, eliminating chances of lead poisoning. Further work was continued on the development of low-temperature glazes of attractive colours, completely free from red lead but possessing all the desired characteristics—good gloss, good covering power and freedom from crazing or peeling. A number of completely lead-free coloured matt glazes maturing at 950-990°C were developed and a readymade glaze batch was sent to the Regional Design Centre for performance trial. The cost of the glazes was brought down from Rs. 5.92 to 1.56 per kg due to the elimination of tin oxide (cost of tin oxide being Rs. 80,000 per tonne) and finally to Rs 0.47 consequent upon the elimination of red lead (cost of red lead taken at Rs 6,000 per tonne). The total annual savings in foreign exchange would thus work out to about Rs. 2 lakh at the present rate of consumption of glazes.**

BOOK REVIEW

(*Continued from page 364*)

in large number ..." etc.) reads as if the species is a thrips (actually it is the host plant), but if the line is joined to the last sentence of the previous para it would be read in proper perspective. Again the last reference cited on p. 20 is not to be found listed at the end.

Although much is left to be desired in its production, *Thrips* would be a useful handbook for any entomologist wishing to have some basic information about the group and its economic importance. No book is available giving such wide and fascinating information in so consise a form. It is recommended both for the general zoologist as well as the field worker.

J.S. BHATTI

BOOK REVIEWS

THRIPS: BIOLOGY AND CONTROL by T.N. Ananthakrishnan, *Macmillan India*, Delhi, Pp. ix+120 8 text-figs., 27 plates, 1974, Rs. 35.00.

VERY little attention has been paid to a study of the tiny insects called thrips or Thysanoptera in India, even though they are practically ubiquitous, and several of the species are harmful to human welfare by being serious pests of crops and horticultural plants, or as agents of viral or other plant diseases. Still others are gall-forming species. Dr. Ananthakrishnan ably underlines the importance of this group by describing the economic role of some selected species. He also introduces the reader to the major aspects of thrips morphology, biology and control.

The book also reflects the intimate studies carried out by the author on this group over the past more than 25 years. The general characters of thrips, their outline classification, affinities and phylogeny, methods of collection and preservation, and rearing techniques are discussed first.

The treatment of ecology deals with their feeding preferences and niches, population fluctuations, their dispersal, and the predatory habits of some species. Several terms frequently used in literature are elaborated here and will be useful to the lay entomologist. The host plant specificity of some species and the polyphagous habits of others are described.

It is surprising that such tiny insects have evolved such diversified feeding mechanisms with peculiar adaptations of mouth parts for specalised feeding habits such as on pollen grains, fungus spores, or on the succulent tissue deep inside fissures on Casuarina trees. The discussion on the nature of damage due to feeding on leaves, flowers or fruit is truly eye-opening as to the depredation these tiny insects can cause, and brings into sharp focus their economic importance.

Twenty species of major thrips pests are discussed with reference to their bionomics and control methods. This should be of practical utility to the agricultural entomologist. Several minor pests (23 species) are also commented upon. The role of thrips in plant gall formation is discussed with a classification of the types of plant galls and a list of common gall-forming species. The transmission of fungal, bacterial and viral diseases of plants by thrips is also discussed.

The appendix gives a comprehensive host-wise list of 110 thrips species found on crops and horticultural plants.

Certain oversights and omissions, however, remain in the book. The families Heterothripidae (of worldwide distribution) and Uzelothripidae (known from South America) are excluded in the table of families of the order Thysanoptera in charts 1 and 3 (pp. 4 and 39). The reader would be curious to know the names of the five species depicted in photographs on plates I to III, although they are meant to illustrate group representatives. The names of authors of species listed in the Appendix are uniformly enclosed within brackets. This is misleading as it gives an impression that every listed species was originally described in a genus different from the one in which it is now treated. Yet there are only 127 out of 289 names listed (40 out of 110 species) which may be so represented. The statement on the rice thrips, *Baliothrips biformis* (p. 54) said to be "highly monophagous" seems misleading. The reviewer has known the species from India, Nepal, the Philippines, and England, and it breeds on several Gramineae. It would have been more useful if all references at the end of the book could have been cited by full page numbers. Several monographs have been cited only by first page number, and full page numbers are often given for smaller papers.

The publication coming from publishers of such repute as Macmillan, should have deserved more editorial care. The book contains many spelling mistakes, particularly with regard to scientific names of thrips and their host plants. The inside flap of the cover jacket contains four mistakes, the "List of Plates" (pp. vi-viii) has 15. A single species is called by more than one name on different pages, e.g., *Ramakrishnothrips cardamomi* on p. vii, but elsewhere as *Sciothrips* (the correct genus name); *Dendrothrips bispinosus* on p. 34, but correctly as *Scirtothrips* elsewhere; *Neolimothrips binervis* on p. 68, but correctly as *Bregmatothrips* elsewhere; *Thrips florum* on pp. 100 and 104, but correctly as *T. hawaiiensis* at other places; *Leeuwenia ramarkrishnae* noted on *Syzygium cumini* on p. 17 but on *S. jambolanum* (sic) elsewhere. On p. 53 (although this is corrected in the "Errata" sheet) the whole first line of para 3 is missing and one line of the preceding para is printed twice. The names "cocoa thrips " and "cocoa plants" (p. 61) are misnomers. Actually these refer to the cacao plant which is the well-known host of the thrips discussed there, whereas cocoa is the plant product derived from the cacao plant. The para 5 on p. 69 ("*Artocarpus integrifolia* occurs

(Continued on page 363)

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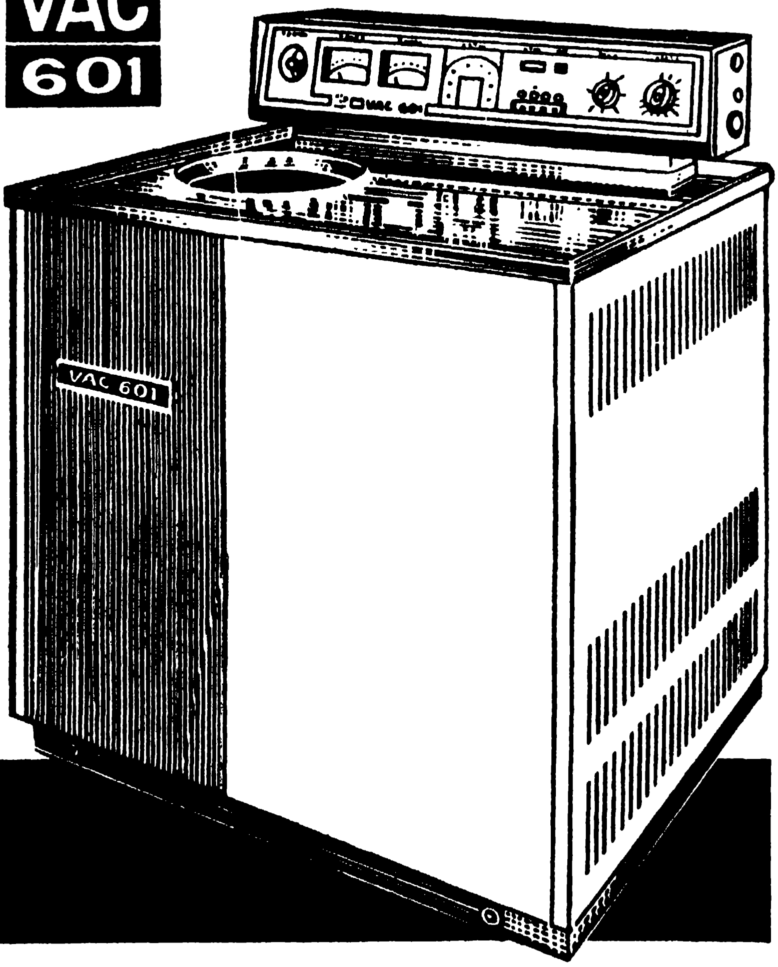

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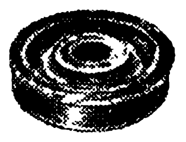

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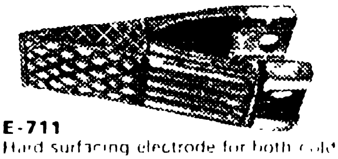

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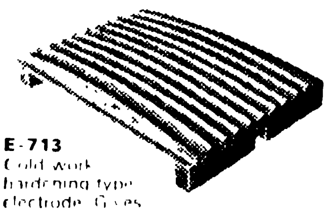

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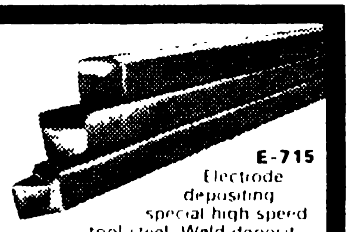

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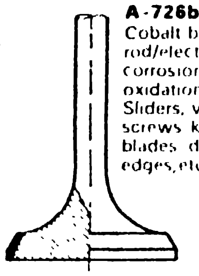

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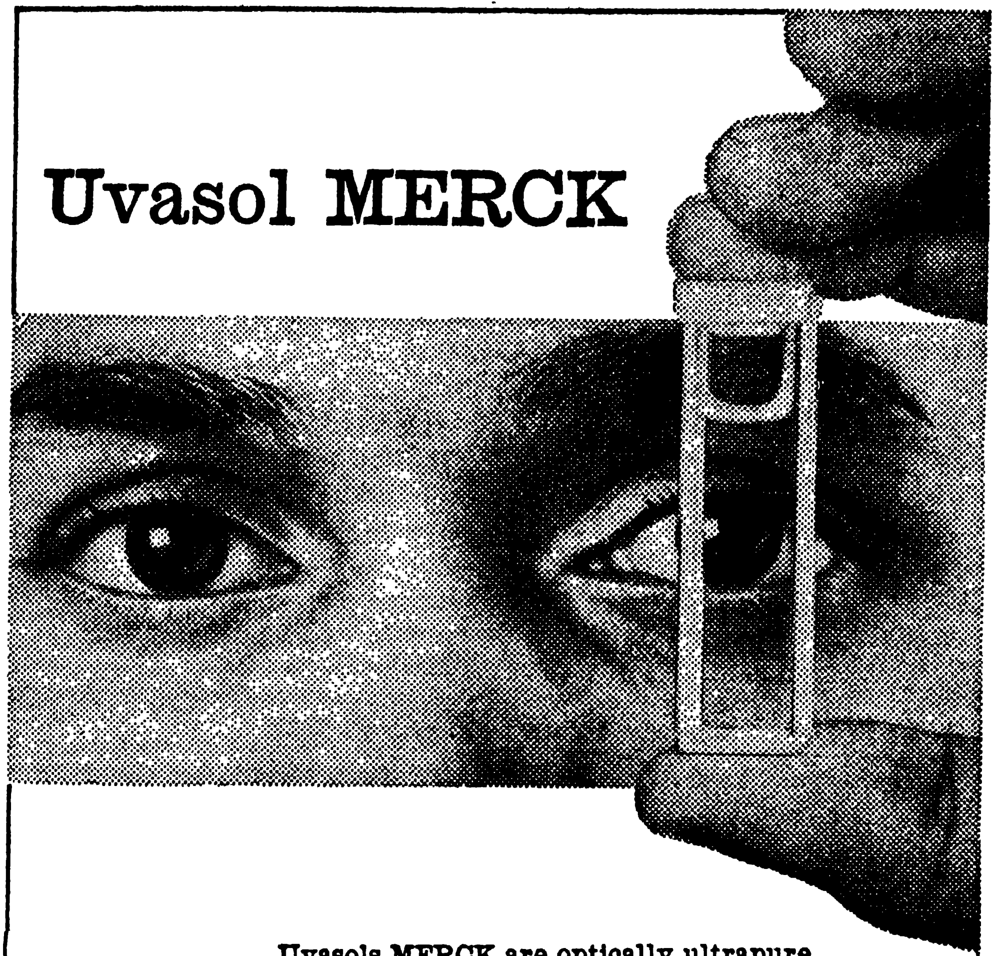

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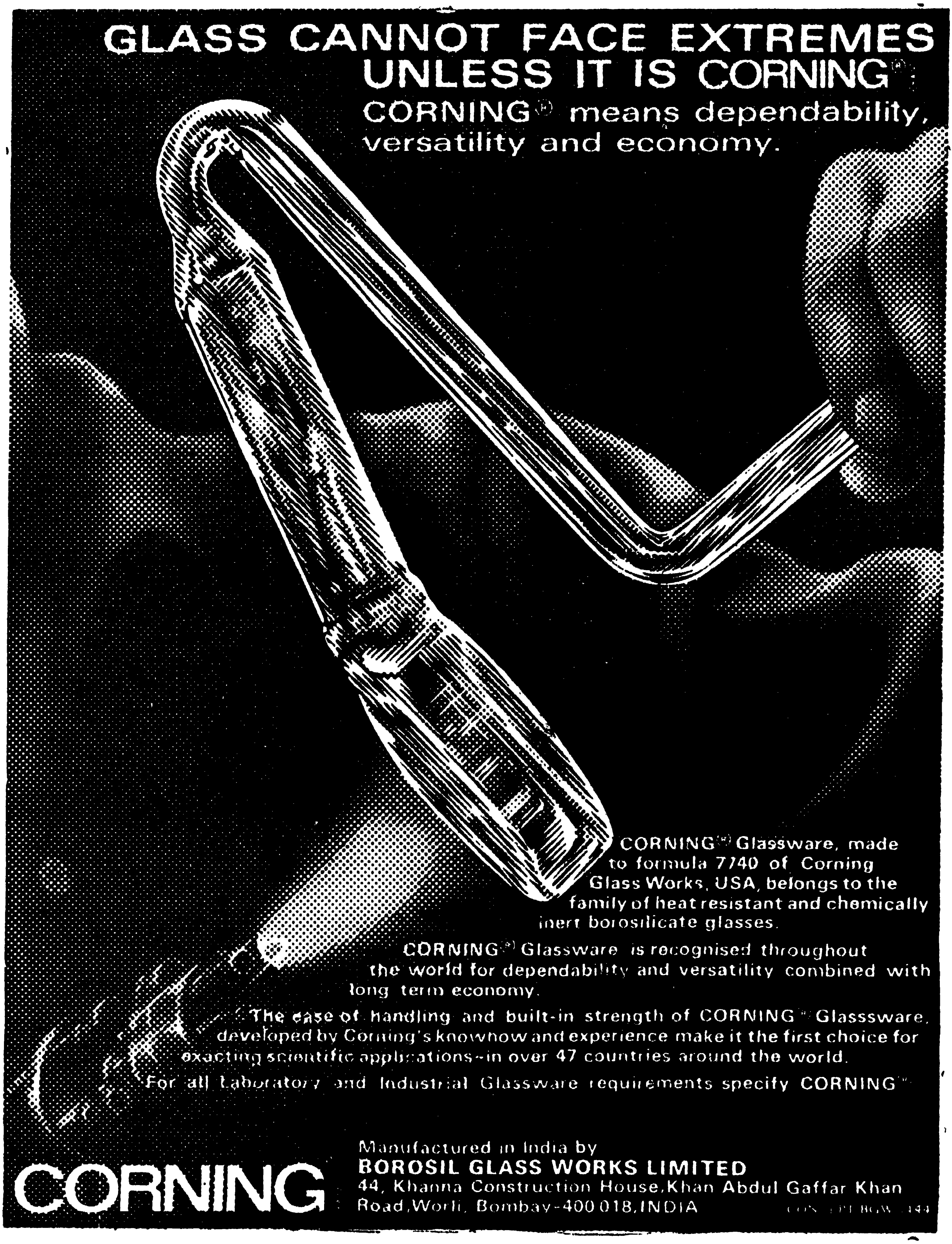

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LETTERS

Are living fossils a challenge ?

Sir, In the article "Living fossil plants—a challenge to evolution" by Vijay K. Sharma and O.S. Singh (*S.R.* January, 1974), it is said that "living fossils are a challenge to evolution and theories which try to explain it are utter failures." In this context I would like to point out the following.

Evolution in the commoner sense means a progressive change in form and structure. The evolution from simple, primitive amoeba to highly complex man occurred only through progressive modification of structure. If this is so, the sporadic incidents of living fossils seem to be a paradox.

A deep study of the mechanism of evolution will easily solve this paradox. Natural selection—the driving force of evolution—in most cases is progressive and produces higher life forms. Under certain circumstances, however, it acts as a conservative force and stabilizes the population. The "stabilized natural selection" then puts a check on the species' future evolution. Living fossils are few of such stabilized populations.

Further, any species would diversify and flourish if it is exposed to wide ecological niches (broader zone of adaptation). On the contrary, if it is exposed to limited ecological niches (narrow zone of adaptation) the chances of diversification and evolutionary modification are also limited. A species which enters this zone cannot evolve further. Its contemporaries that enter the broader zone, however, become modified and highly evolved.

The present day individuals of the coelacanth, limulus, or sphaenodon resemble their good old ancestors. They are not a challenge to evolution but are the products of another evolutionary phenomenon, namely, stasigenesis. This is applicable to all plants and animals.

N. KANNAN
American College
Madurai, Tamil Nadu

Urinalysis

Sir, I read the article "What does urinalysis tell?" (*S.R.* June, 1974). The article gives us a simple explanation about the various physiological and pathological constituents of urine. I would like to add the following.

Apart from normal constituents like chlorides, phosphates, urea, etc., various other factors like hippuric acid, indican, sulphates and neutral sulphur are also present. Hippuric acid, formed by benzoic acid uniting with glycine in liver, is excreted in small amounts (0.7 gms). Potassium salt of indoxyl sulphate (indican) is excreted about 5.25 mg/day. Indican is derived from indole in liver, the latter formed in the large intestine by bacterial action on tryptophan. In achlorhydria, obstructive jaundice, and paralytic ileus increased excretion of indican is observed.

Sulphates excreted are of two types—inorganic and conjugated or ethereal sulphur. These are derived from proteins such as cystine and methionine. Inorganic sulphur is present as the fully oxidised sulphur. This can be precipitated from urine by barium chloride. 10% of excreted sulphur is in conjugated form, often conjugating with cresol or phenol forming skatoxyl and indoxyl sulphuric acids. They can also be precipitated using hydrochloric acid and barium chloride.

The incompletely oxidised form of sulphur is represented by neutral sulphur. It is derived from cystine, taurine, thiocyanates, etc. Glucuroic acid occurring in urine has two forms—ester and glycosidic—amounting from 0.3 to 1.0 gm. This is increased by the administration of acetyl salicylic acid, sulphonamides (except sulphanilamide), antipyrene, and phenolphthalein. Citrate is excreted in amounts from 0.2 to 1.2 gm/day. It is increased by the administration of estrogen and decreased by androgen.

Patients suffering from "primary aldosteronism" (secretion of excess of aldosterone by adrenal tumor) retain more sodium and excrete less of it usually below the normal value of 2 to 4 gm/day.

In certain congenital diseases such as phenylketonuria, and alkaptonuria, amino acids are excreted. Ochronosis results from alkaptonuria where homogentisic acid is liberated in urine as such. Hence urine blackens on exposure to air. Phenyl pyruvic acid may also be excreted due to partial oxidation of phenylalanine resulting in phenylketonuria. All amino acids may also be excreted in Fanconi's syndrome. In a peculiar condition a hetero protease called Bence Jone's protein may also be excreted.

G.N. LAKSHMI NARAYAN
Coimbatore Medical College
Coimbatore

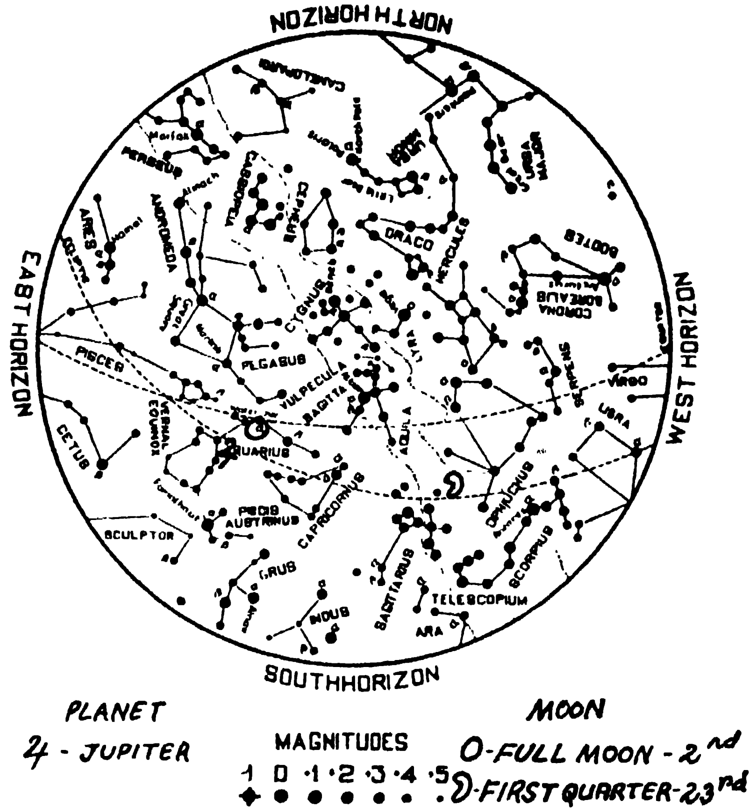
Soybean products

Sir, I am a regular reader of *S.R.* I found the article "Soybean—an ideal food" written by V. Bhaskar in June 1974 issue most interesting and educative. I am sure it would serve very useful purpose particularly to the people in India.

The author has said that a Japanese food manufacturer has prepared a meat substitute from soybean after extracting the oil from the seeds. May I draw the attention of the author as well as the readers of *S.R.* that in India a farm in Uttar Pradesh is manufacturing and marketing textured soy-protein known as

(Continued on page 396)

PLANETS AND THEIR POSITIONS—SEPTEMBER 1974



The moon

FULL moon occurs on 2nd at 0-55 a.m. and New moon on 16th at 8-15 a.m. I.S.T.

The moon passes about seven degrees north of Jupiter on 2nd, two degrees south of Saturn on 11th, about seven degrees south of Venus on 15th, three degrees south of Mercury on 18th and again seven degrees north of Jupiter on 29th. The lunar crescent becomes first visible after the new moon day in the evening of 17th.

The moon is at perigee or nearest to the earth on 14th and at apogee or farthest from it on the 26th.

The sun is at the autumnal equinox on 23rd.

The planets

Mercury (Budha) reappears as an evening star and sets about an hour after sunset during the month. It passes about half a degree north of the star Spica (*Chitra*) on 22nd. It moves from Leo (*Simha*) to Libra (*Tula*) through Virgo (*Kanya*). Its visual magnitude varies from —0.4 to +0.2.

Venus (Sukra), a morning star, rises about an hour before sunrise during the month. It passes about a degree north of the star Regulus (*Magha*) on 8th. It moves from Cancer (*Karkata*) to Virgo (*Kanya*) through Leo (*Simha*). Its visual magnitude is about —3.4.

Mars (Mangala) is too near the sun to be visible during the month. It moves from Leo (*Simha*) to Virgo (*Kanya*).

Jupiter (Brihaspati) rises at about sunset and sets at about sunrise during the first half of the month being at opposition with the sun on 5th. During the second half it sets about an hour before sunrise. It is in Aquarius (*Kumbha*). Its visual magnitude is about —2.4.

Saturn (Sani), visible in the morning sky, rises about an hour after local midnight during the first half of the month and at about local midnight during the second half. It is in Gemini (*Mithuna*). Its visual magnitude is about +0.4.

(*Source:* The Nautical Almanac Unit of the Meteorological Office, Alipore, Calcutta-27)

TO OUR READERS

Due to circumstances beyond our control the printing of our July and August issues has been delayed. We are trying our best to bring it on schedule. Till we are able to do so, we earnestly hope our readers will bear with us.

WEATHEROMETRICS—MATHEMATICS OF WEATHER

WG. CDR. A.G. GARDE

Though individual intuitive skill is essential in weather forecasting, the use of mathematics in meteorological research is to reduce this dependence on an individual to the minimum

HELD-FAST to the earth by the force of gravity is a vast ocean of air. One of about a dozen of its components is water vapour which is able to pass very easily into the liquid and solid states and vice versa. The changes of state liberate or take up large amounts of heat. Into this blanket of air the sun pours energy in the form of short wave radiation. Much of it is reflected back to space from vegetation, water and by clouds. A little is absorbed by the air and the remaining goes to heat the earth. The heated earth, in turn, gives out long wave radiation some of which is absorbed and re-emitted by water vapour and clouds and some is lost to space. The balance-sheet of radiant energy shows changes with the time of the day, season, locality, the composition of the atmosphere and also with the distribution of land and water over the globe. The unequal heating sets up currents in the atmosphere transporting huge masses of air from one location to another. During the course of the long journey the air masses pick up moisture at one place and release it at some other place. This is what we call weather.

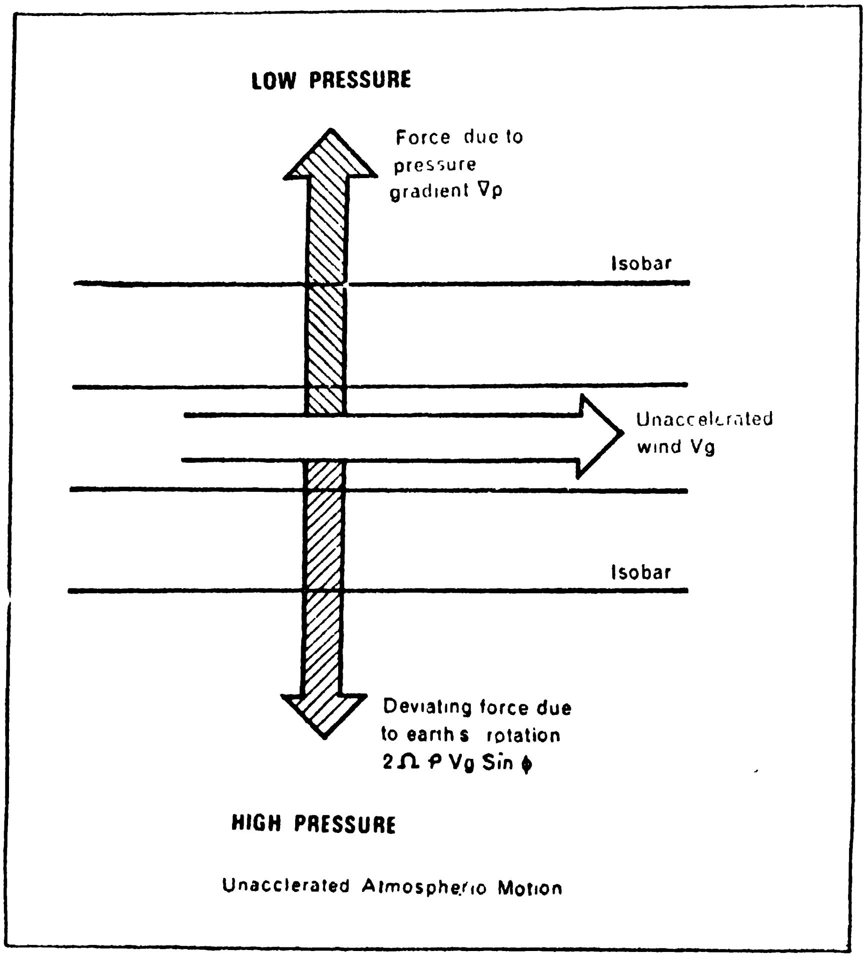
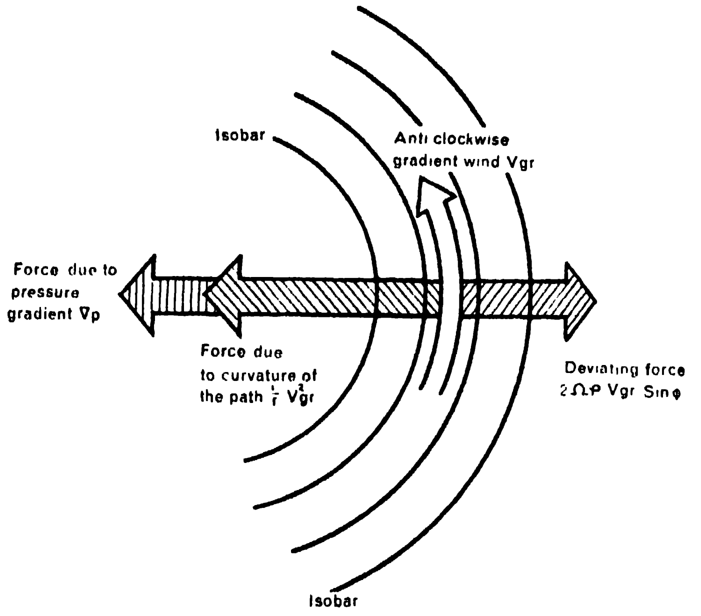

LOW PRESSURE
Force due to pressure gradient ∇p
Isobar
Unaccelerated wind Vg
Isobar
Deviating force due to earth's rotation $2\Omega\rho V_g \sin\phi$
HIGH PRESSURE
Unacclerated Atmospheric Motion

Fig. 1.

Wg. Cdr. Garde is Chief Meteorological Instructor at Air Force Admn. College, Coimbatore.


Isobar
Anti clockwise gradient wind Vgr
Force due to pressure gradient ∇p
Force due to curvature of the path $\frac{1}{r} V_{gr}^2$
Deviating force $2\Omega\rho$ Vgr $\sin\phi$
Isobar

Accelerated (curved) Atmospheric Motion

Fig. 2.

Atmosphere—a complicated steam engine

The whole system of atmospheric motions and the manifestation of weather can be visualised as an incredibly complicated steam engine with the sun as the furnace and the highly heterogeneous envelope of the earth as the transmission channel. There are no regular periodicities in the atmosphere as in the case of eclipses, tides, etc.; nor have simple causal relations between the states of atmosphere at different times so far been laid down. In order to bring weather within the scope of exact mathematical analysis, we need precise knowledge of the initial and boundary conditions. When we realise that there are large areas of the globe such as parts of oceans, deserts and polar caps for which there are no meteorological records, the definitions of the initial and the boundary conditions meet with serious obstacles. Because of insufficient knowledge and the complexities involved, many problems can hardly be stated at the present time. But this has not deterred the scientists and they have approached the problem by highly idealising the atmosphere and its laws. The approximate solutions thus obtained are made more and more exact by making the definitions more and more stringent.

The atmosphere at rest

If we consider that the atmosphere is stationary and has the same temperature throughout the column, the following relationship is found to hold:

$$p = p_0 e^{-gz/RT_m}$$

where z = height above the reference point,
p_0 = pressure of the atmosphere at the reference point,
p = pressure at a height z,
T_m = mean (absolute) temperature of the column,
R = gas constant, and
g = acceleration due to gravity.

It should, however, be remembered that neither the atmosphere is at rest nor does it have the same temperature at all heights. Inspite of such drastic assumptions the above equation depicts conditions which are not radically different from those observed in the atmosphere.

Motion in the atmosphere

The typical equation of motion of an incompressible viscous fluid is:

Inertia force = Viscous force
+Force due to pressure gradient
+External forces.

This is known as Navier Stoke's equation. This equation together with the equation of continuity, using the principle of conservation of mass, determines, at least theoretically, velocity and pressure at any position and time.

Unfortunately these equations cannot be solved so easily. In these equations the intertia terms are nonlinear. Therefore it is not possible to build up the complete solution by adding together simple solutions. The speeds encountered in the atmosphere are not so small as would permit removal of squares and product of velocities Even though the speeds are not comparable to that of sound, the atmosphere cannot strictly be taken to be incompressible. For this reason it is necessary to take into account the equations of thermodynamics also.

Richardson's dream

L.F. Richardson, an English meteorologist, was the first to have attempted to solve the equations of motion after specifying the initial and boundary conditions. In 1922, when he made an attempt, the meteorological observations, specially in the

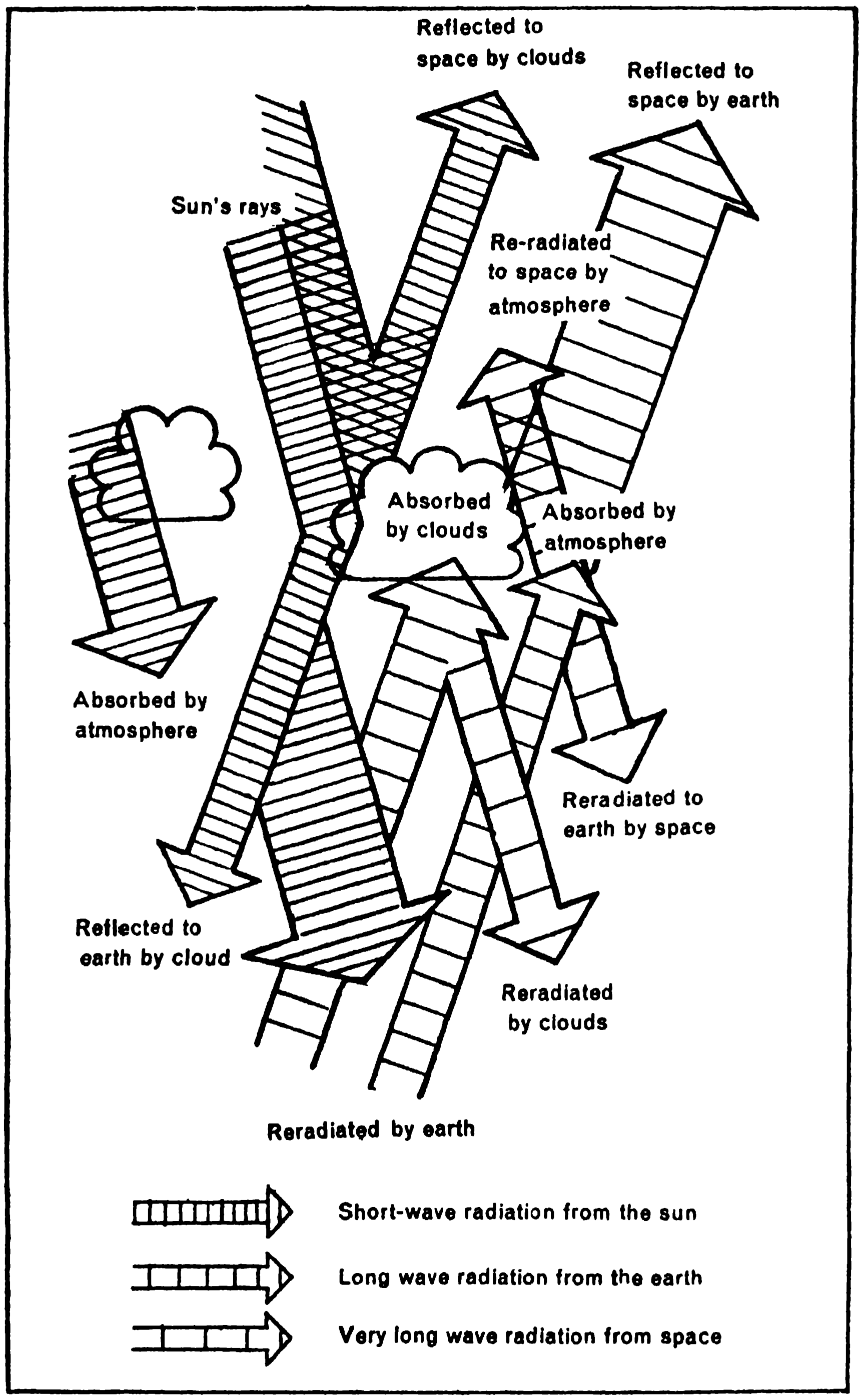

Reflected to space by clouds
Reflected to space by earth
Sun's rays
Re-radiated to space by atmosphere
Absorbed by clouds
Absorbed by atmosphere
Absorbed by atmosphere
Reradiated to earth by space
Reflected to earth by cloud
Reradiated by clouds
Reradiated by earth
Short-wave radiation from the sun
Long wave radiation from the earth
Very long wave radiation from space

Fig. 3. Balance sheet of radiation energy in the terrestrial atmosphere

upper air, were too sparse. Electronic computers had not even been thought of. His failure was therefore quite natural. But his effort indicated that his method was the only feasible line of attack to solve the problem. However, inspite of vast networks of observatories and electronic computers working at incredible speeds, today we are not very near the realisation of his dream.

Today's weatherman is less ambitious than Richardson. If he can solve a simplified model he is satisfied; for by gradual refinement he can expect to find a solution to the actual problem.

The simplest model

The simplest model of the atmosphere is obtained by making the following assumptions:

(a) The wind blows horizontally only, i.e., there is no vertical motion.

(b) Frictional effects of the ground are absent, and

(c) The motion is steady, i.e., it is independent of time.

These over-simplifications do not render the atmosphere unrealistic. There is still a great resemblance between the model and the actual atmosphere. Under these assumptions only the following two forces produce the horizontal motion:

(a) Force due to the gradient of pressure, and

(b) A fictitious force due to earth's rotation, which causes every moving particle to deviate to its right in the northern hemisphere. This force is called the Coriolis force.

It would be interesting to know that the Coriolis force acts on all bodies moving in the atmosphere including a bullet or even a cricket ball. This effect may not be perceptible, though, in these short range flights. But a correction has to be applied for this effect in long range bombing.

The simplest type of atmospheric motion with some claim to reality is obtained by assuming the atmospheric motion to be unaccelerated, i.e., the winds flow in a straight path and the stream lines are parallel. A somewhat better approximation is obtained by taking into consideration the effect of the curvature, clockwise or anticlockwise, of the path of wind.

That these are valid approximations can be proved not only by actual measurement of the wind, straight or curved, but also by an equally interest-

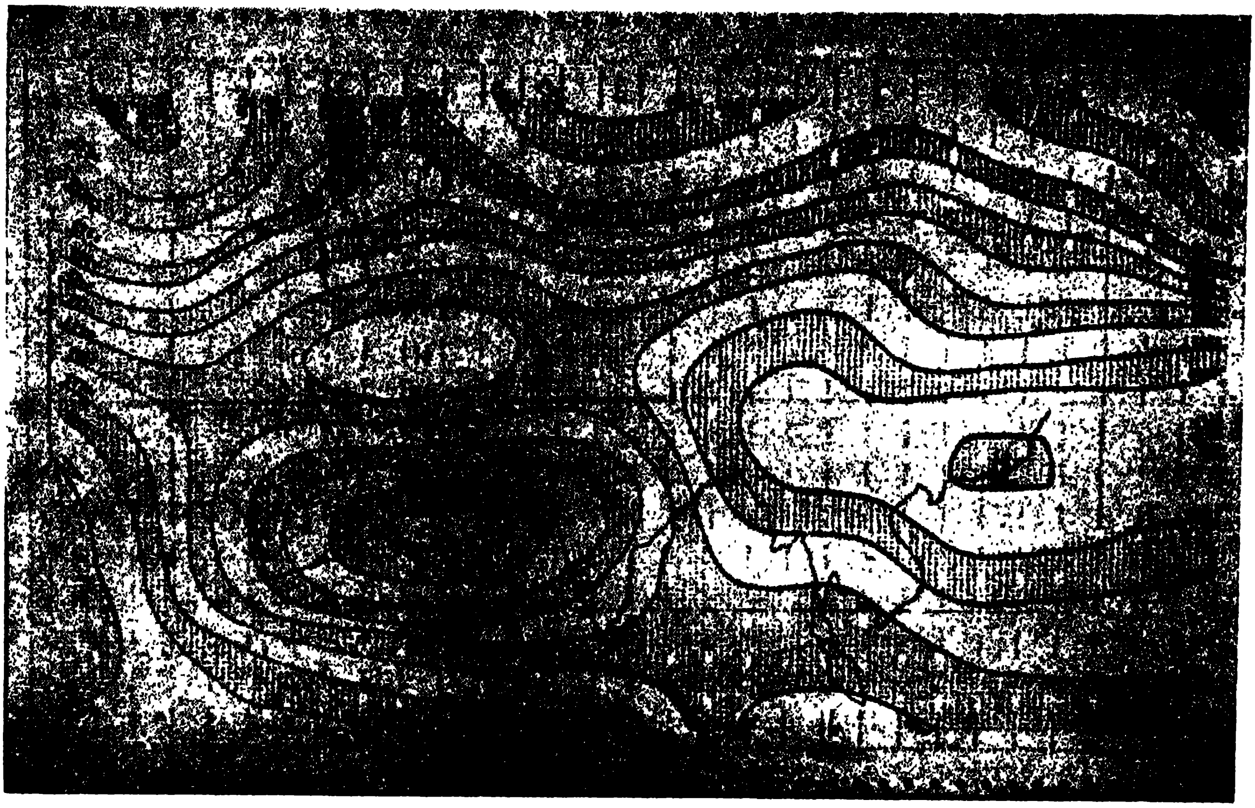


Fig. 4. Numerical forecast valid for 1-7-1972 (00 GMT)

ing deduction verified by observations. Whereas there is no limit to the speed of winds associated with a cyclone, the winds in an anti-cyclone cannot exceed a certain strength. In spite of such a conclusive validity of this assumption, this has no direct bearing on the problem of forecasting weather. We have seen above that in this model vertical motion is absent. And, there can be no sequence of weather without vertical motion.

Classical forecast of weather

In order to estimate the possibilities of mathematical weather forecasting we need to know something about the methods which are used by official weather forecasters today.

There is a network of observatories which supply in large numbers observations from the ground and the upper air. Though the observations are available in three dimensions, what a meteorologist studies is a number of horizontal sections. It is sometimes more advantageous to study a section not at a specified height above the earth's surface but a section at a specified atmospheric pressure. A few vertical views complete the three-dimensional picture. He then does what is called "Air mass analysis" and delineates the lines of discontinuities, zones of convergence and vertical motion, etc.

Statistically definite kinds of weather are associated with particular patterns of pressure or wind distributions. Calculations in the strict mathematical sense are rarely done. The weather forecaster has to combine the physical reasoning and an intelligent guess of changes in pressure pattern, with his past experience. Obviously the degree of success falls rapidly as the period lengthens except of course when the pressure field is very stable. Thus in addition to his possession of the profound theoretical knowledge of the subject the weather forecaster should have an aptitude and physical insight to score some measure of success in this difficult art.

Modern forecasting techniques

Though the individual skill in weather forecasting can never disappear, the employment of mathematics in meteorological research is to reduce this dependence on an individual to as small a degree as possible. It has been stated above that it is advantageous to observe the changes in the surfaces of equal pressure rather than the changes of pressure patterns in surfaces at a specified height. Such an analysis is called 'contour' analysis (or thickness analysis); for the contours of any surface describe that surface completely. What we are interested in usually is the change rather than the absolute value of any element. This is achieved by analysing the patterns of thickness between two or

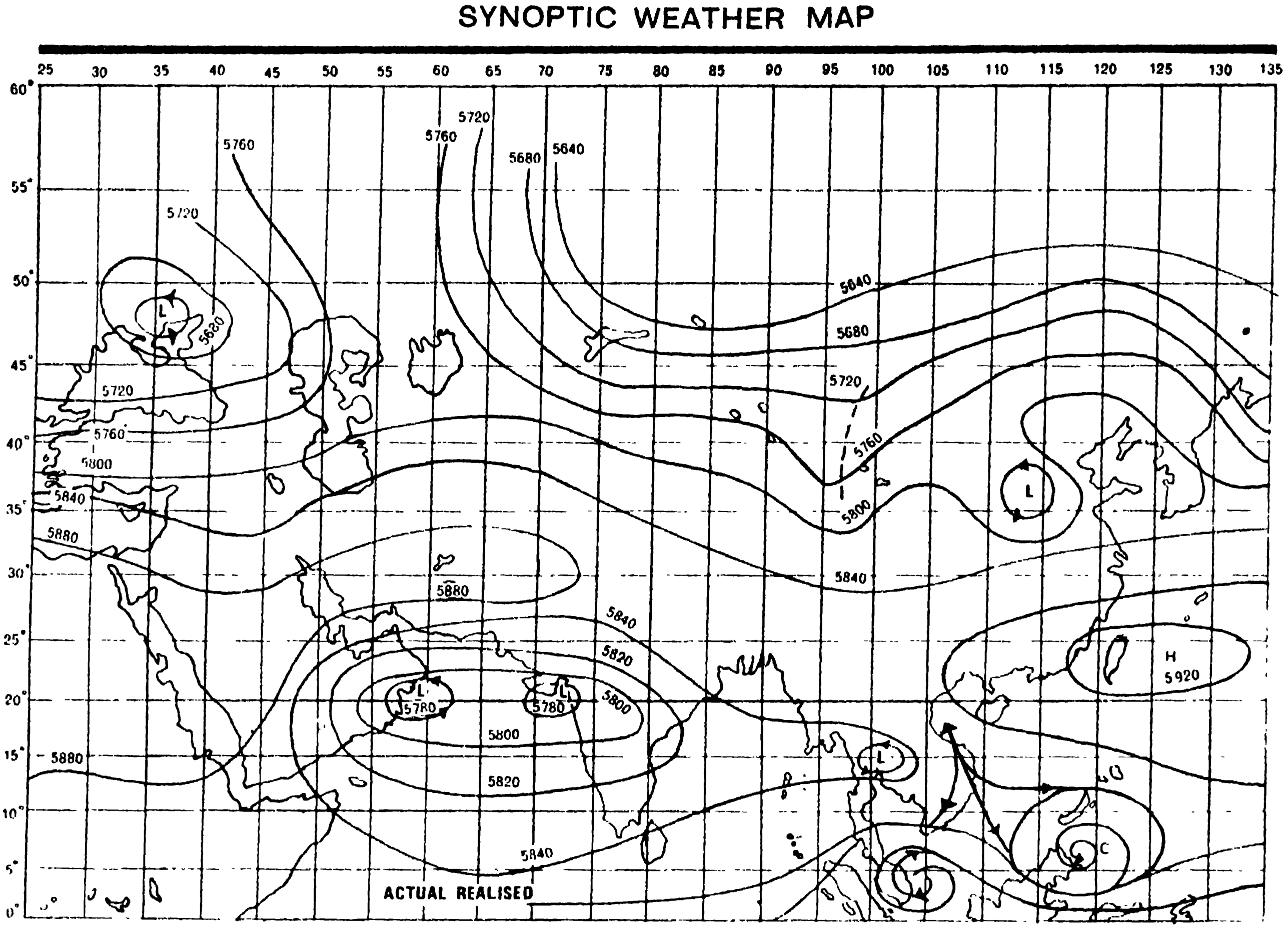


Fig. 5. Weather map actually realised on 1-7-1972 (00 GMT)

more surfaces of standard pressures. Remembering that the density varies inversely as the temperature, it is easy to see that two surfaces of specific pressures are separated by larger thickness if the mean temperature of the intervening air column is high. Thus consideration of thickness patterns automatically takes into account the thermal structure of the atmosphere. Since the contours of a pressure surface depend on the base pressures and therefore on patterns of the isobars on the surface of the earth, contour patterns give all the information that surface pressure pattern would give.

Many hydrodynamical problems can be solved by employing what is known as the principle of conservation of vorticity. Theoretical meteorologists have used this principle, rather by a circuitous route to forecast changes in the contour and thickness patterns. On a rotating earth it is the absolute spin of the atmosphere which is the sum of the spin of earth and the spin of the atmosphere relative to the earth that is conserved. The spin in the horizontal plane or about a vertical axis depends on the distribution of horizontal velocities which can be inferred from the distribution of surface pressure which in turn can be inferred from the contours of pressure surface. The conservation of absolute spin in the atmosphere which is itself in motion implies that any change in the local magnitude of the spin must be attributed entirely to the transport of that entity from the neighbourhood.

From the initial value of the local rate of change of spin the new distribution of spin and then the new shape of the pressure surface after a very short interval of time can be calculated. By the iterative process the final shape of the desired pressure suface can be calculated.

For the forecast to be accurate and available sufficiently in advance the contour heights should be calculated at as large a number of points as possible and steps of the iterative process should also be as numerous. This was the dream of Richardson half a century ago. It is about to become a reality because of the growth of observational network and the invention of electronic computers.

(Continued on page 387)

SPONGE IRON

HEM SHANKAR RAY

Integrated with electric furnaces, sponge iron production facilities can play an excellent supplementary role in steel industry

IN recent years there has been a world-wide interest over alternative methods of steelmaking which bypass the blast furnace. The controversial Bharati Process, which claims a revolutionary approach in steelmaking,is actually one of the hundreds of processes that have been proposed. Many of these are mere ideas on paper whereas others have been evolved after repeated experimentation and pilot plant trials. The more successful processes have almost ushered in a new era in steelmaking. India is not far behind in this major technological development and proposals for sponge iron production and consequent conversion of sponge to steel are receiving serious attention.

What is sponge iron?

Sponge iron is not soft and spongy as the name might appear to imply, but a solid, porous metallic mass. The metallic mass is called a sponge because of its appearance—a honeycomb structure with minute holes all over the surface and the bulk. Produced through solid-state reduction of iron ore, it acquires this peculiar appearance because of escape of gaseous reduction products through the mass of ore which itself loses weight as a result of reduction.

Such a solid-state conversion is often referred to as direct reduction. The word 'direct' merely implies that this is an approach to steelmaking without recourse to the blast furance. The sponge-like product can sometimes be used in the blast furnace itself for pig iron production at lower coke rates. In such a case it is referred to as pre-reduced iron ore—the name merely implying that considerable reduction has been carried out prior to blast furance operation.

Direct reduction or pre-reduction is a process in which most of the oxygen is removed in the solid state. The resulting product retains the original shape; powder (which may be briquetted later), pellet or lump. The product is essentially metallic iron but not completely so. In other words, the extent of metallization is less than hundred per cent. We may add that the extent of reduction of the oxide feed is also less than hundred per cent.

The degree of reduction is a measure of the weight of oxygen removed from the original material. The oxygen comes not only from iron ore, say Fe_2O_3, but also from other oxygen-containing compounds in gangue. It can be easily shown that the degree of reduction is always greater than the degree of metallization which is the ratio of weights of metallized (free) iron and the total (combined) iron. This is so because while oxygen is removed both from the iron mineral as well as the gangue, the metallic iron is produced only from the iron-bearing compound. The degree of metallization achieved in sponge iron production should be 85-90 per cent or more if it is to be used in electric furances for steel production.

Why produce sponge iron?

Sponge iron production is now widely recognized as a necessary step in augmenting steel production all over the world. It has been forecast that steel production will reach a world total of 735 million tonnes in 1975 and 915 million tonnes by 1980. Production and consumption of sponge iron are expected to equal 11 million and 62 million tonnes respectively for the corresponding years. It should be noted, however, that the importance of sponge iron production cannot be measured in terms of tonnage alone. Sponge iron

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Dr. Ray is Assistant Professor, Department of Metallurgical Engineering, Indian Institute of Technology, Kanpur

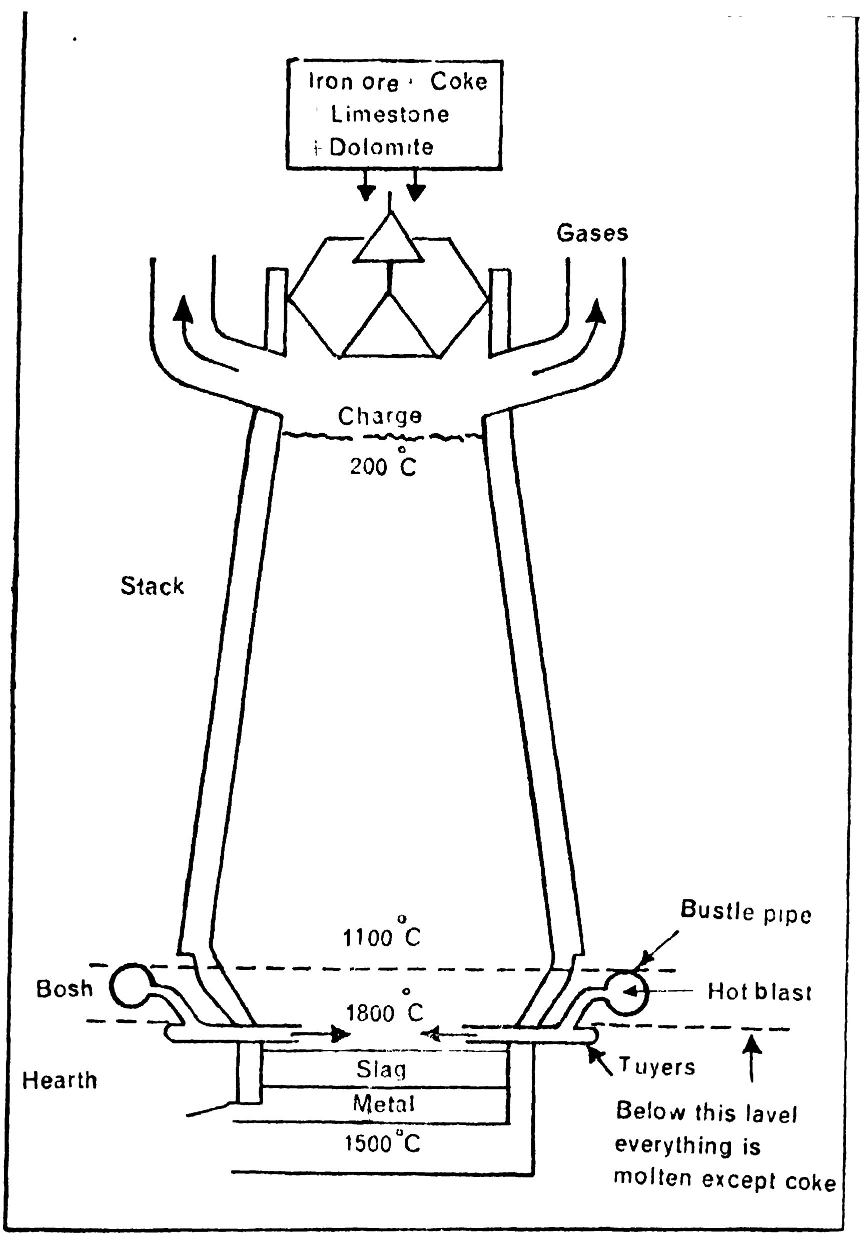

Fig. 1. Schematic diagram of blast furnace

plants may be located in regions unsuitable for conventional iron and steel works. Integrated with electric furnaces for smelting of steel these sponge iron plants could give rise to mini steel plants which would be the ideal answer to local demands.

Before we discuss the merits of sponge iron production in greater detail we should perhaps take a look at some of the main features of the blast furnace production of pig iron.

A schematic diagram of the blast furnace is shown in Fig. 1.

The blast furnace charge consists of iron ore, coke and fluxes $CaCO_3$ and $MgCO_3$. The main products are liquid slag and liquid pig iron containing about 6 per cent of impurities. This pig iron is subsequently converted to steel by selective oxidation of the impurities such as C, Mn, Si, P, etc.

Blast furnace operation depends heavily on good quality coke. The coke should not only be relatively high-grade with as little impurities as possible but it must also be strong. It should be noted that in the furnace hearth every other component of the charge, except coke, is liquified, The solid coke lumps not only support the burden but also ensure porosity in the charge for escape of hot gases. If the coke particles were to crumble, the entire furnace operation would be in jeopardy.

All over the world, and particularly so in India, metallurgical coking coal is only a fraction of the total coal reserves. In India the total coal reserves have been estimated at about 1,09,000 million tonnes. Of this only about 12,000 million tonnes are of prime and medium coking quality. Consequently many people foresee shortage of coking coal in near future.

Traditional blast furnace process faces other difficulties too. Because of its enormous capacity it is economical only when integrated in steel plants with steel making units and rolling mills. The plant has thus to be necessarily a colossal venture. For example, even a one-million tonne plant would involve a capital outlay of over Rs. 250 crores, take years for completion, and require thousands of workers and operators. Moreover, plants of this nature have to meet stringent conditions of right location in terms of raw material deposits, transportation facilities, soil conditions, labour supply, regional industrial environment, etc.

In spite of these limitations it is improbable that blast furnace process would become obsolete in near future. However, sponge iron production facilities can play an excellent supplementary role in steel production by producing in mini steel plants steel from sponge iron. The capacities of these plants would be a tenth or even less compared to the conventional integrated steel plants. Besides, condition of location,

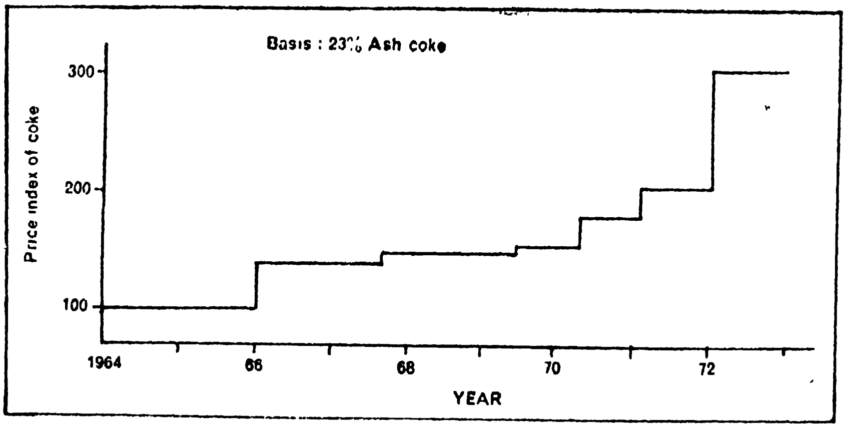

Fig. 2. Rise in the price of coke

coal requirements, capital, etc., would be far less stringent.

Sponge iron as a substitute for scrap

The share of electric furnace steel in the total world steel production is steadily rising. Mini steel plants are mushrooming all over the world. As a result, the demand for scrap is increasing and many developing countries in particular are already facing difficulties in procuring their scrap requirements. This situation together with the recent development of continuous feeding of sponge iron in electric arc furnace that would effect significant lowering of heat-time has aroused world-wide interest in sponge iron. Sponge iron is now accepted as an ideal feed in electric steelmaking.

At present the world capacity of sponge iron for steelmaking is about 2.8 million tonnes and is expected to rise to 4.6 million tonnes when the plants now under construction are completed. According to a recent estimate, because of scarcity of scrap, the demand of sponge iron for steelmaking will be around 11 million tonnes by 1975 and 42 million tonnes by 1980. How does India figure in this situation? Today there are around 180 arc furnaces in operation and many more are in the process of installation. Because of the rising demand of steel scrap its price has doubled between 1968-72. It is anticipated that by 1980 there would be a shortfall of over 6,00,000 tonnes of scrap. This shortfall must be made up by sponge iron production.

It should be noted that the mini plants would not be able to produce steel more economically compared to integrated iron and steel plants. A cost comparison is given in Fig. 3. Yet, for strategic reasons, the mini plants must be there.

In addition to the various advantages in sponge iron production there are, of course, some negative points too. The capital investment in direct reduction plants, per tonne of iron output, is very high. There is also at present lack of expertise in this area. It is believed, however, that these difficulties can be overcome through establishment of more and more commercial units.

How is sponge iron produced ?

Sponge iron is produced through reduction of iron ore by solid or gaseous reductants. Solid reductant would be coal. The gaseous reductants are mainly mixtures of CO and H_2. Such reducing gases may be obtained through producer gas reactions or by steam reforming of

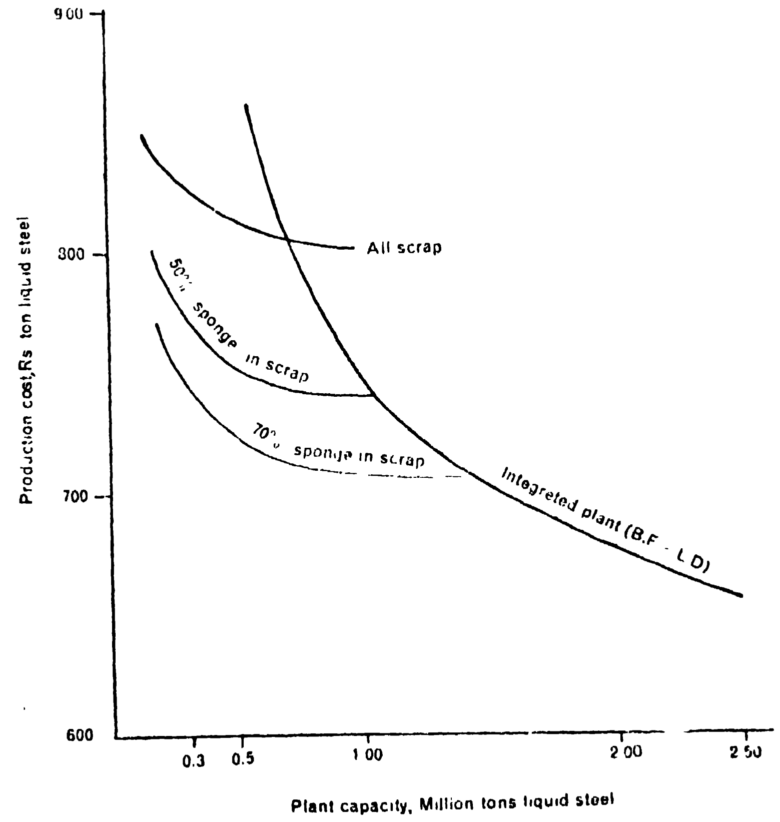

Fig. 3. Cost comparison of integrated steel plant and mini steel plant operation

natural gas which is mostly methane. The reactions are, respectively, as follows.

$$C + H_2O \xrightarrow{\text{about } 1000^{\circ}C} CO + H_2$$
$$CH_4 + H_2O + \text{heat} \longrightarrow CO + 3H_2$$

In India only very limited supply of natural gas is available in Assam and Gujarat. This is not enough to sustain commercial reduction processes. All direct reduction units in India, therefore, must depend on use of reducing gases generated from coal or the solid coal itself as reductant.

The chemical reactions accompanying reduction are often very complex. However, the main reactions are,

1. Gaseous reductants

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2 + \text{heat}$$
$$Fe_2O_3 + H_2 + \text{heat} \rightarrow 3Fe + 3H_2O$$

2. Solid reductants

$$Fe_2O_3 + 3C + \text{heat} \rightarrow 2Fe + 3CO$$
$$Fe_2O_3 + 1.5C + \text{heat} \rightarrow 2Fe + 1.5CO_2$$

Here both reactions are endothermic (i.e., heat absorbing). The second would, however, be preferred because it consumes less carbon.

Commercial processes

There are several ways of classifying the numerous direct reduction processes. Firstly, one can draw a distinction between processes using solid reductants and those using gaseous reductant. In all cases reactions occur at temperatures of around 1000°C or lower. Gaseous reductant processes have made better progress apparently because of easier handling of gaseous reductants compared to solids.

From the operational point of view we may list the following categories.

Fixed bed processes. Here the reactor charge remains relatively undisturbed throughout the reduction process. Reducing gases pass through the bed. Uniform gas flow and efficient heat transfer all over the bed have to be carefully ensured.

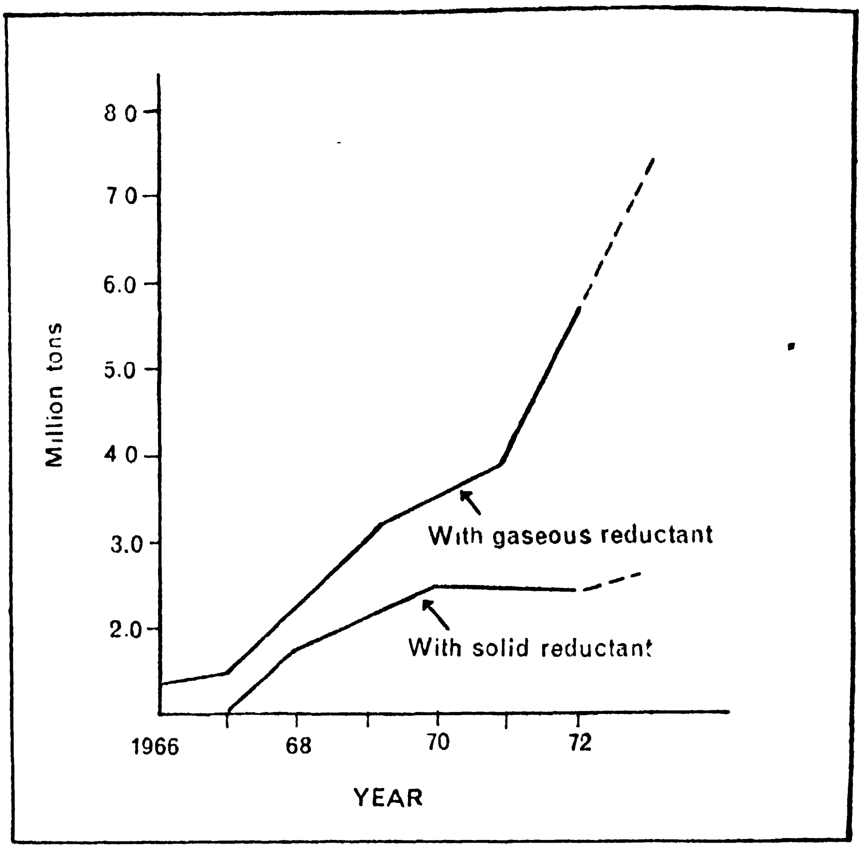

Fig. 4. Growth of world sponge iron capacity

Fluid bed processes. Here the charge material is suspended in the reactor vessel by upward flow of heating/reducing gases. The process requires uniformly sized fine particles of ores as well as some other stringent conditions. These processes are yet to be developed fully.

Rotary kiln processes. In these processes the reaction chamber consists of an inclined rotary kiln which is rotated. The reductant is a solid carbonaceous material usually charged with iron oxide. Multiple burners along the length of the kiln maintain uniform temperature.

Shaft processes. Here iron-bearing charge is allowed to descend along a vertical shaft while hot reducing gases flow upwards.

In India pilot-plant trials using rotary kilns have been carried out at the Indian Iron and Steel Company at Burnpur and at the National Metallurgical Laboratory, Jamshedpur. The results have been encouraging. Shaft processes are being investigated in some educational institutions.

The Bharati Process

Patents for the controversial Bharati Process were taken by Iqbal Krishna Bharati in 1962. The process envisages production of CO through gasification of coal in the first instance. This CO, mixed in a given proportion with hydrogen, is then introduced and circulated in a closed rectangular reactor containing iron ore. After direct reduction is over, the solid metallized product is pushed out by a rammer in the same manner as coke is discharged from coke ovens.

The Technical Division of TISCO and subsequently a government committee headed by Dr. V.A. Altekar, Director of National Metallurgical Laboratory, Jamshedpur, both expressed serious doubts about the feasibility of this proposed process. In the Bharati Process some 110 tonnes of ore are reduced to about 70 tonnes of metallized product. It may not be easy to push this out in a manner used in coke ovens. The rammer and the reactor walls may be seriously damaged. There are possibilities of CO leakage and reoxidation of the hot metallized output when it is discharged in cold air. It is also doubtful if heating and reduction in a massive static bed as proposed will be uniform and efficient. There may be localized overheating with formation of clinkers and consequent lack of bed porosity causing serious blockade of gas flow.

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    - (i) M.N. Dastur, C.R. Parthasarathy and T.K. Roy, 'The future of direct reduction processes'
    - (ii) S. Das Gupta, J.C. Agrawal and B. Roy, 'Application of solid reductant processes for direct reduction in India'.
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Science and Technology Plan 1974-79 (Draft)

Draft Science and Technology Plan prepared by the National Committee on Science and Technology in two volumes is now on sale. Vol. I of the plan (Price Rs. 10/-) spells out the guiding philosophy underlying the S & T Plan and highlights the areas where technological efforts need to be directed. Vol. II (Price Rs. 50/-) gives detailed projects and programmes under the various sectors.

Copies may be obtained from the Under Secretary, N.C.S.T., (Deptt. of Science & Technology), Technology Bhavan, New Mehrauli Road, New Delhi-110029 against a Demand Draft drawn in his favour.

davp 647(3)/74

HORMONES AND GENE EXPRESSION

A.P. SHARMA AND S.K. AGGARWAL

The enzyme, adenyl cyclase, is probably activated by the released hormone to catalyse the formation of c-AMP which, in turn, results in the phosphorylation of histones, with consequent de-repression of DNA template followed by RNA and protein synthesis

THE elementary act of gene expression consists of many consecutive steps. They are: binding of DNA-dependent RNA-polymerase on to the chromosomal deoxynucleoprotein template; synthesis of messenger RNA (*m*-RNA) on this template; removal of newly synthesized RNA from the enzyme-template complex; formation of a transport ribonucleoprotein complex for transfer of *m*-RNA into the cytoplasm; formation of polysomes; and the synthesis of protein in polysomes. There are possibly other steps involved as well. All the above steps may be the points of regulation of the process as a whole, and this explains the great complexity of the phenomenon of gene expression. It is not possible to consider all the possible points of regulation here. We shall review only the effect of hormones on the most significant point of gene expression, that is, the biosynthesis of *m*-RNA.

Hormone action sites

Although one way or another hormones participate in almost every biological process operative in the mammalian organism, the primary site of hormone action is still confusing. Five general sites, all intimately related, have been proposed: (i) induction of enzyme synthesis at the nuclear level; (ii) stimulation of enzyme synthesis at the ribosomal level; (iii) direct activation at the enzyme level; (iv) hormonal action at the membrane level; and (v) hormonal action as related to the level of cyclic-AMP.

All the five mechanisms may be involved in the action of a given hormone and may vary in significance when the action of a hormone is studied in different tissues. For example, insulin has a major and rapid effect on membrane-transport in adipose and muscle tissue, but its action is slower in liver where it may function at nuclear and/or translation level.

The emergence of molecular biology, with its spectacular achivements in elucidating the process of information transfer from genes to proteins (transcription and translation) and genetic regulation of protein synthesis, has made it possible to propose a unified mechanism for all hormone actions. The current hormone-gene hypothesis of action is that hormones produce their characteristic effects by regulating genetic programming which is expressed in terms of enzyme formation and subsequently followed by change in cellular metabolism. In this article the biochemical basis of hormonal induction is described.

Hormone-receptor complex

Whatever be the method or mechanism of regulation, there is one universal feature of all control mechanisms. This concerns molecular recognition. Theoretical considerations and experimental observations support the assumption that the hormone molecule is inscribed with an instruction for a target cell to execute a final response. The response is hormone specific but may also be target specific. After being released in response to an endogenous or exogenous stimulus, the hormone reaches the target tissue and forms a complex with a specific receptor system. During the complex formation the receptor reads, translates, and amplifies the hormone-carried

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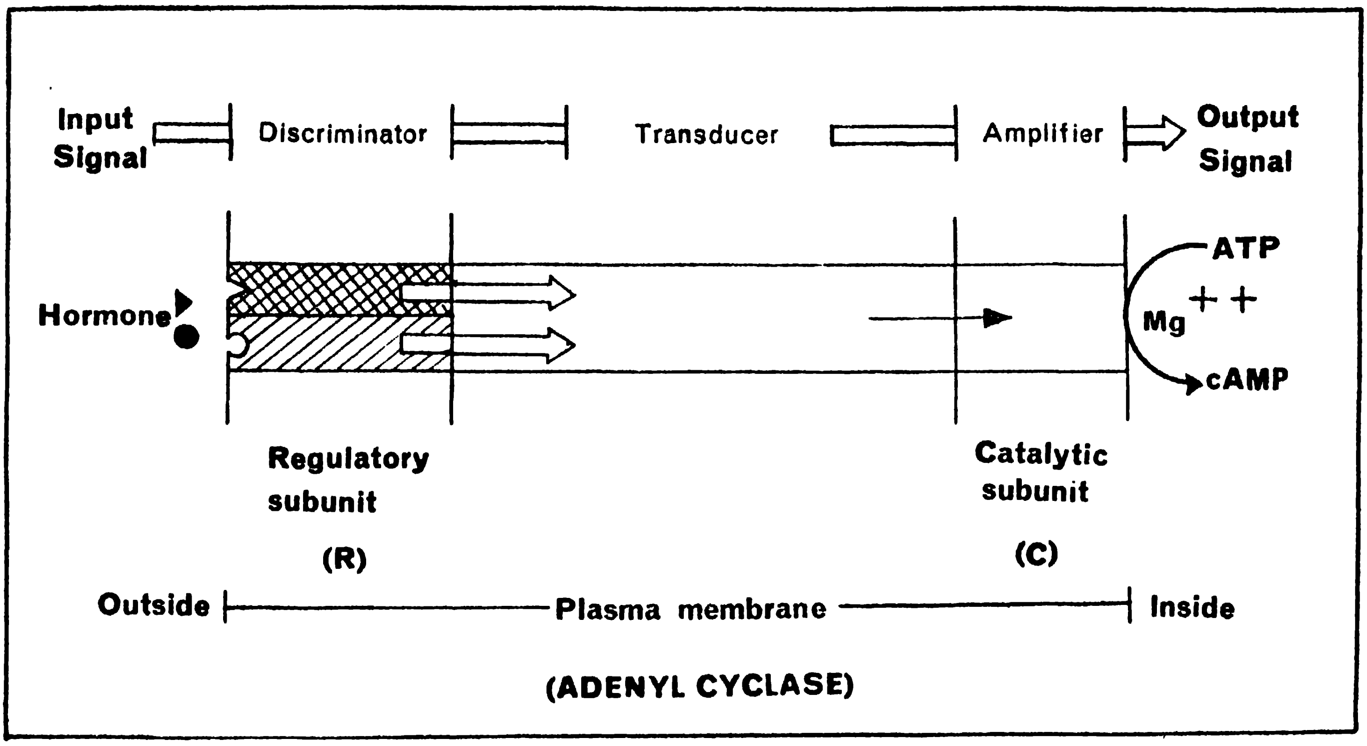

Fig. 1. Plasma membrane receptor system for hormones

message. The receptor system seems to consist of three components to perform three different functions. They are: (i) the discriminator, which helps select the message (specificity for hormones); (ii) the transducer, which converts the signal coming from discriminator and feeds it into the amplifier; and (iii) the amplifier, that recognises the instruction to accelerate the catalytic function (Fig. 1).

The discriminator, transducer, and the amplifier can co-exist on a single molecule and the possibility of this system, collectively referred to as adenyl cyclase, as a multimolecular complex, cannot be ruled out. Adenyl cyclase is a widely distributed enzyme which in a variety of tissues has been found in the cytoplasmic membrane. By now, no less than twelve tissues have been found in which membrane bound adenyl cyclases respond to different hormones.

A possible model of adenyl cyclase system which provides a useful working hypothesis is that it consists of at least two types of subunits, a regulatory subunit facing the extracellular fluid and a catalytic subunit with its active centre bordering the interior of the cell. Interaction between part of the regulatory subunit and the relevant hormone leads to a conformation perturbation which is extended to the catalytic subunit, altering the activity of the latter, which leads to synthesis of cyclic-AMP. (Fig. 2).

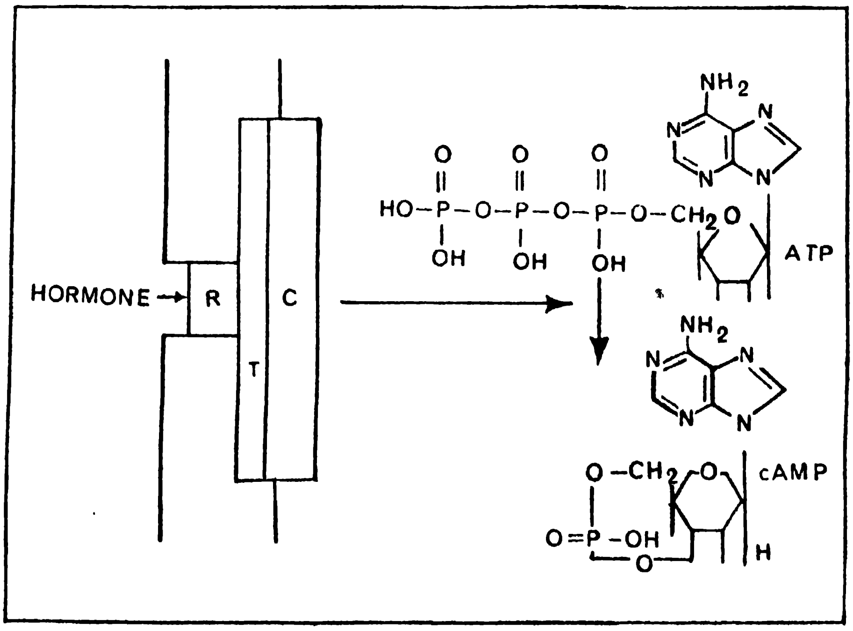

Fig. 2. Structural model of membrane adenyl cyclase and synthesis of cAMP. R—regulatory subunit, C—catalytic subunit, T—transducer

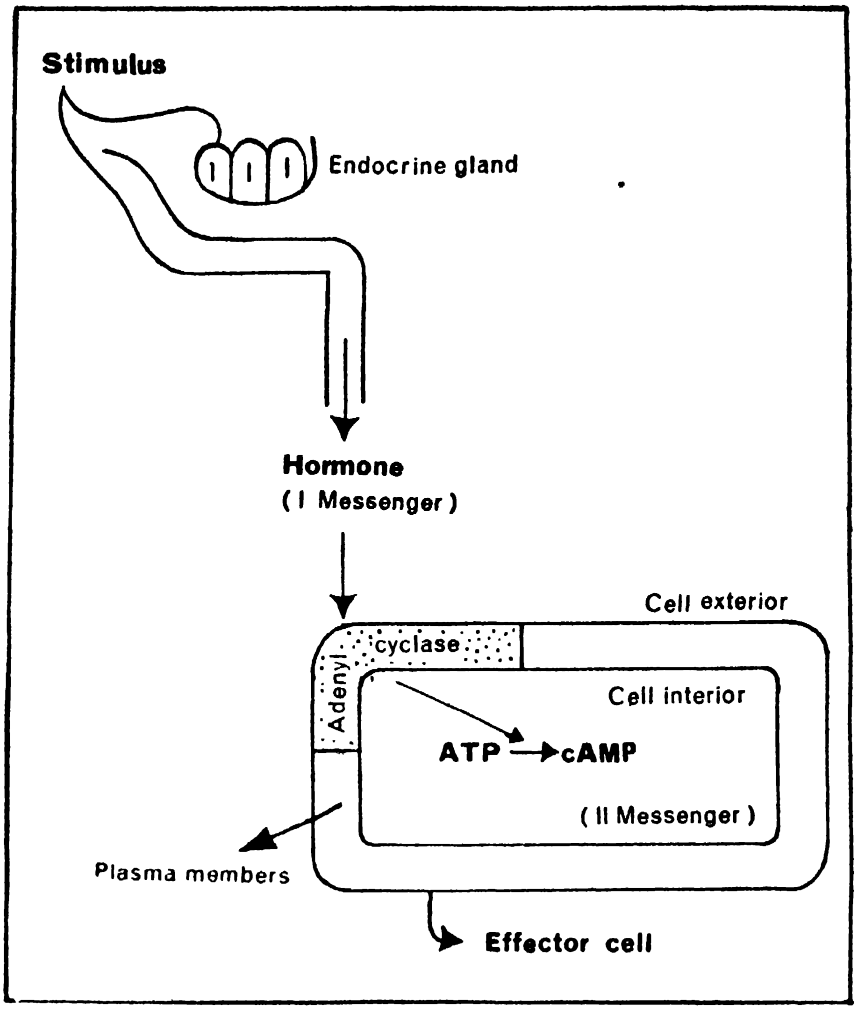

Fig. 3. Two-messenger concept of hormone action

Execution of hormone-carried message

Hormonal control (direct or indirect) of gene expression has been demonstrated or suggested by morphological evidence and more recently by an increasing accumulation of biochemical data. However, at present, it is difficult to visualize a single functional model whereby the different types of hormones could act in the control of RNA and protein synthesis. E.W. Sutherland (1968) suggested a generalized hypothesis that hormones act by a two-messenger system (Fig. 3). The concept suggests that an endocrine gland receives a stimulus and responds by releasing the first messenger, the hormone itself (the terminology is unfortunate, and these messengers must not be confused with *m*-RNA), which travels to the cells of target tissues where they interact. At the site of interaction, usually the plasma membrane, the hormone-receptor complex induces neo-synthesis of the second messenger (c-AMP) that is inscribed with receptor-mediated hormone-carried message. After coupling to its specific receptor system, the second messenger functions as an internal inducer. It activates a special set of regulatory and metabolic processes that are best suited to execute the hormone-carried message, thus producing the real effect of the hormone.

The most popular hypothesis comes from the work of P. Karlson (1963) who states that hormones act by modifying the activity of genes, some genes being activated and others repressed. Although recent advances in developmental and molecular biology have provided the background for this concept, it is mainly based on the experimental observations with ecdysone. Ecdysone, an insect hormone, is also known as molting and metamorphosis hormone (Fig. 4a). Ecdysone has been shown to influence the chromosomes by producing puffs at one or two gene loci. These puffs also occur during the course of normal development in the transition from larvae to pupae, presumably induced by endogenous ecdysone. It was shown that most of the DNA bands can undergo reversible puffing, and the puff(s) was interpreted as special action structure(s) of the genetic material. In biochemical terms the genetic information is read and transferred to the cytoplasm to direct the synthesis of specific protein or enzyme (Fig. 4b).

Also relevant here is the concept of gene repression and induction formulated by F. Jacob and J. Monod (1961). According to this hypothesis, the enzyme is under double control. Molecular organisation (i.e., amino acid sequence) of enzyme protein is controlled by structural genes through the synthesis of *m*-RNA, while the rate of *m*-RNA is controlled by operator and/or regulator genes. The activity of these genes is in turn regulated by repressors which

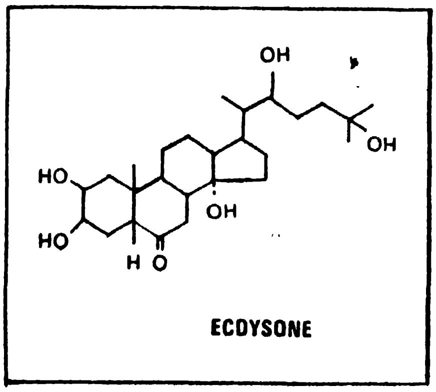

Fig. 4. (a) Moulting hormone

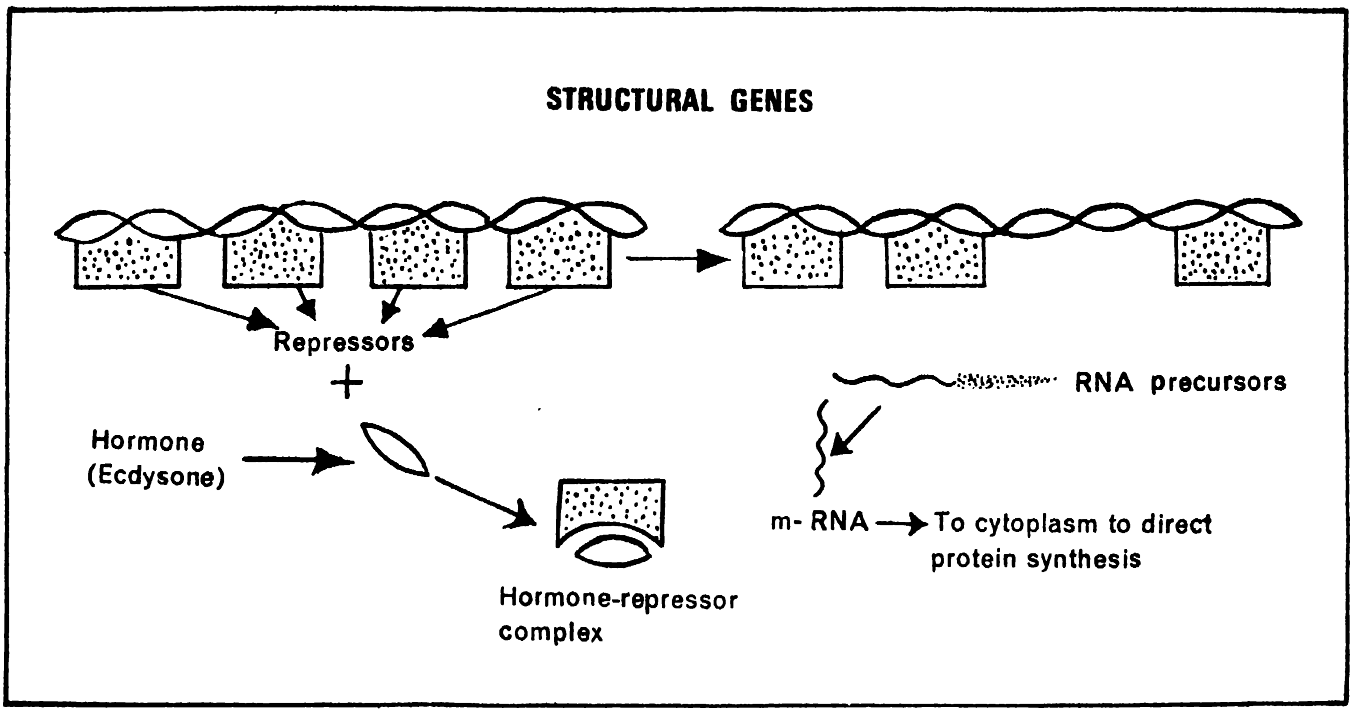
STRUCTURAL GENES
Repressors
+
Hormone (Ecdysone)
Hormone-repressor complex
RNA precursors
m- RNA
To cytoplasm to direct protein synthesis

Fig. 4(b). Induction of synthesis of new protein (DOPA-decarboxylase) by a hormone acting as a derepressor

exert a negative influence, i.e., they block the gene action. All repressor molecules exist in active and inactive forms depending on whether they are combined with highly specific small molecules, "inducers" and "co-repressors". The inducer inactivates the repressor. In contrast, the binding of co-repressor changes an inactive repressor to an active one. If the inducer behaves as a substrate, the substrate is regarded as an enzyme inducer (Fig. 5).

Ecdysone induces the neo-synthesis of DOPA-decarboxylase enzyme by de-repressing the particular DNA segment. Inhibitors of RNA and protein synthesis prevent the induction of this enzyme. It is believed that the primary action of hormones is to stimulate synthesis of specific *m*-RNA molecules. A large body of evidence seems to support this view, at least for some hormones. Other hormones, however, merely stimulate RNA polymerase activity or general protein synthesis (translation) without apparent differential effect at the level of genome.

Recently it has been suggested that ecdysone produces its effects on the genes by altering the permeability and trasnport functions of the cell membrane and/or nuclear membrane. It seems that ions act directly upon the chromatin, possibly on DNA-histone links. The ions could compete with histones for the negative charges on DNA molecule and cause a displacement of histone from its position on DNA. This would result in the revealing of masked stretches of DNA which could act now as a template for RNA synthesis.

The histones, long known as constituents of cell nucleus, are believed to be gene regulators or DNA insulators. Histones are rich in basic amino acids, lysine and arginine. They insulate the DNA molecule through ionic linkagess between anionic phosphate groups of DNA and cationic groups of the basic amino acids. The binding of hormone to histones is, therefore, of particular interest in this context; it can be visualized that the molecule would thus be modified so that it no longer serves as insultor. This could have morphological consequences (finally resulting in a puff structure) and biochemical implications. The exposed portion of the DNA strand could serve as a template for DNA-dependent RNA-polymerase.

Is this mechanism unique to ecdysone, or does it also apply to mammalian hormones? Mammalian cells, of course, lack giant chromosomes, so that the interaction of any mammalian hormone with the genetic material cannot be observed directly. However, one can draw several conclusions which should be detectable in mammalian systems. Circumstantial evidence for de-repression of genes by hormones is provided by the specific interactions of hormones with DNA, histones, and nuclear receptor sites different from extra-nuclear receptors thought to be

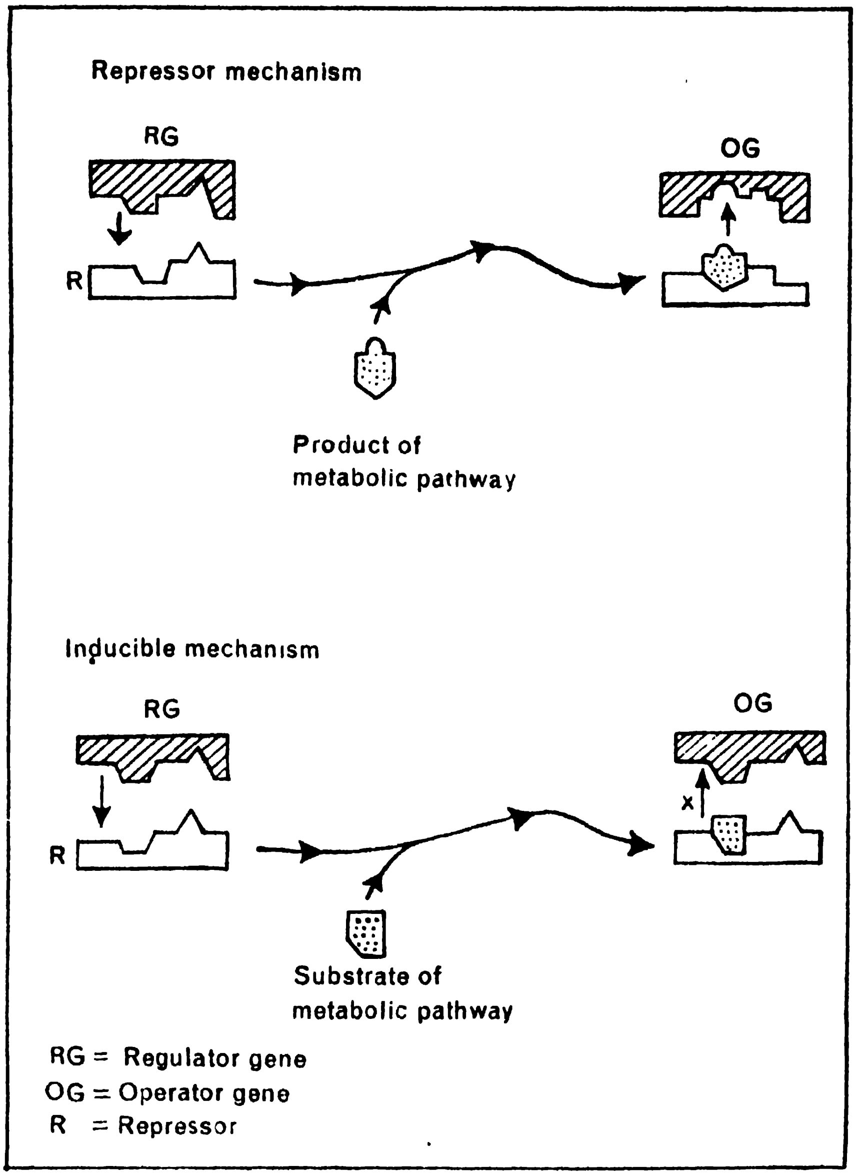

Fig. 5. Mechanisms of repression and induction

involved in hormone uptake. Hormones have been shown to enhance acetylation of histones which are supposed to regulate the priming capacity of chromatin. Polypeptide hormones usually deliver their message while passing through the cell membrane of the target tissue. Steroid hormones seem to require both the cellular and the nuclear mechanisms.

As mentioned earlier, the level of c-AMP increases in response to several mammalian hormones. A role for c-AMP in regulating transcription and/or translation of genetic information is implied by numerous observations. For example, it acts as a mediator of hormone responses which involve the synthesis of new proteins, blockade by inhibitors of proteins, or RNA synthesis. The enzyme, adenyl cyclase, is activated by the hormone to catalyse the formation of c-AMP. Cyclic nucleotide probably activates histone kinase resulting in the phosphorylation of histones, with consequent de-repression of DNA template followed by RNA and protein synthesis (Fig. 6). It is interesting to note with respect to the possible effects of hormones at the translation level, that c-AMP stimulates polypeptide chain release from polysomes. Hormones may also function by complexing with target protein and unmasking the repressed segments of DNA.

It has been proposed that the main role of c-AMP is to modify membrane function. This hypothesis implies that this compound could affect the activity of ion-sensitive enzymes and possibly the synthesis of enzymes. Recent observations, that chromosomal changes take place at the same time as growth induces changes in the permeability of the nuclear membrane, lend some support to the role of membranes in hormonal action on protein synthesis. The participation of the cell nucleus in hormonal effects is also indicated by the increase in volume of nucleus and nucleolus, and a change from heterochromatin to euchromatin following administration of hormones.

Regardless of the sequence of events following hormone treatment, the role of RNA in the action of some hormones is based on the widely observed findings: (i) inhibitors of RNA synthesis suppress hormonal effects on enzyme synthesis; (ii) stimulation of RNA synthesis usually preceeds the enhancement of enzyme synthesis following administration of hormones *in vivo*, in tissue culture or in tissue slices; (iii) hormones fail to enhance protein synthesis in cell-free systems when administered *in vitro*, whereas synthesis is increased when hormones are given *in vivo*; (iv) a few minutes after administration of hormones *in vivo*, an increased template capacity of chromatin is observed when its activity is tested *in vitro*; (v) DNA-RNA hybridization studies indicate that new types of rapidly turning over RNA are synthesized subsequent to exposure to hormones.

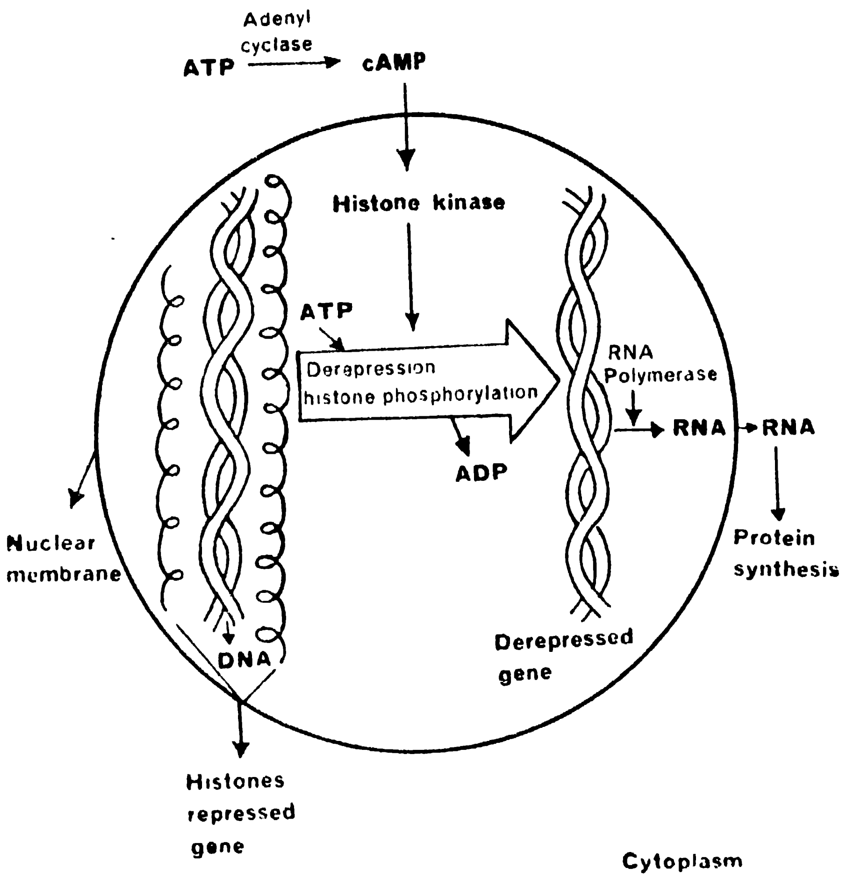

Fig. 6. Hormonal induction of RNA and protein synthesis mediated by cyclic-AMP

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WEATHEROMETRICS

(*Continued from page 376*)

Computers vs. man-made forecast

One would form an impression that having removed the only two difficulties which came in the way of Richardson, a breakthrough in meteorological forecasting is round the corner, and that the proverbial unreliability of weather forecast would be removed for ever. However, what computer has achieved is only the speed in computation; the basic comprehension of the atmospheric processes is still left for man to understand. Besides, effect of random extraneous influences such as bursts of cosmic radiation, urbanisation, deforestation, industrialisation, or sun-spots to mention only a few, cannot be brought within the scope of strict mathematical analysis. Further the computer has solved only simplified equations of motion in the ideal atmosphere. Though the departure from ideal conditions is unlikely to affect seriously the forecast of weather over a large area, the detailed problem of local forecasting of weather, of rain or snow or fog or frost will still have to be solved by experienced forecaster for good many years to come. Obviously, the computer cannot think!

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ISOTOPES REVEAL INSIDE OF PLANTS

V. KUMAR AND P. C. PANDE

Metabolic pathways in plants can be conveniently studied using isotopic tracers

THE rapid progress in the last decade in biology, especially at the molecular level, has provided new and more fundamental insights into living systems. Many important discoveries which have redefined and broadened our concepts of biological phenomena are attributable to the development of new techniques and instrumentation. One of the most important of these has been the wide use of isotopes as labels or analytical tools in biological research, e.g., in tracing and elaborating the major steps in the metabolic systems.

What is an isotope?

A 'radioactive isotope' or briefly 'radioisotope' is the radioactive counterpart of a stable element. In other words, they are atoms exactly identical in all respects to normal elements except in one property—radioactivity. Isotope tracer atoms, which may also be non-radioactive, have a 'tag' or label on them which makes them instantly recognizable amongst a large number of normal atoms. This tag may either be the radioactivity or the different mass of the atom. It enables one to observe the course the atoms follow in chemical or biochemical reactions. For all practical purposes, chemical or bio-chemical behaviour of an isotope remains identical to that of the original element. This is the most important condition for the use of isotopes as tracers. The radioactive molecule under investigation expresses its distinctiveness only at the moment of disintegration of the isotopic atom within it. An element can be made radioactive by irradiation with high energy particles from nuclear reactors.

The rate of reactions is to some extent influenced as the isotopes differ in mass from the normal ones. This sometimes causes difficulty with complex biological systems where reactions do not usually reach completion. But this has again proved beneficial to researchers in elucidating the mechanisms of enzymatic reactions.

Another problem with radioisotopes is that the emission of radiation causes ionisation which in turn causes cell damage. Beta emitters are very dangerous to tissues, because this radiation is readily absorbed by aqueous medium and may cause genetic damage. So, to decide the proper dose for a particular experimental animal or a homogenate, the investigator has to take into account two main factors—the radioactivity and the quantity.

Apart from these, some ill effects upon health are also noticed which can be overcome by proper shield protection, control and careful handling of waste disposals and by properly designing the laboratory.

Selection of isotopes

The isotopes used as tracer elements are usually stable, i.e., they do not easily degenerate. Some of the widely used stable isotopes are those of carbon, hydrogen, nitrogen, oxygen, sulpher, etc.; their choice depending upon the nature of the investigation and the extent to which the labelled isotopes are lost in the process. One of the most important factors for selection of a radioisotope is its life period. Very short-lived isotopes provide only a limited time for observation and hence are not of much use. On the other hand, long-lived isotopes emit only neglegible amounts of radiation which are difficult to detect. Further, some isotopes emit large quantities of radiation and may render irrepairable damage to

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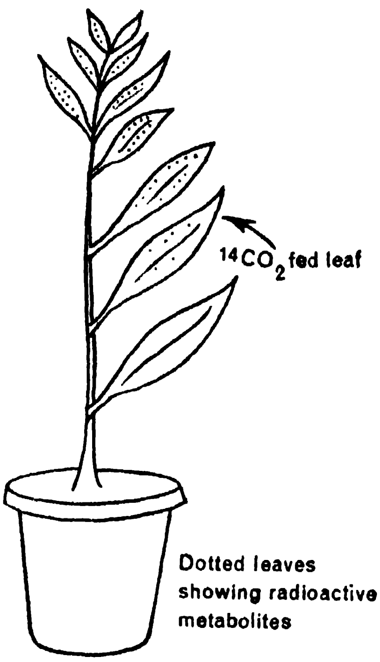
$^{14}CO_2$ fed leaf
Dotted leaves showing radioactive metabolites

Fig. 1. Joy's (1964) experiment showing tangential movement

the tissue under investigation or the observer. Therefore, most useful radioisotopes are those which have long life periods and emit radiation continuously. Such isotopes usually have life periods from a few hours to several thousand years.

Detection of radioisotopes is comparatively simpler than finding out their concentration because they emit one or the other type of radiation. Usually the method employed to locate the radiating substance is to expose some radiation-sensitive paper or film to the tissue containing the radioisotopes. The process is called autoradiography. To find out concentration of radioactive assimilate, the quantum of radiation is measured —a method which is also dependent upon the type of radiation emitted. The common measuring devices are: electroscope, ionization chamber, scintillation counter, proportional counter (e.g., Geiger Muller counter), etc.

Applications

The first application of radioactive isotopes to plant studies was made by G. Hevesy and F. Panith in 1913. They fed a radioactive isotope of lead ^{212}Pb and Thorium-B nitrate to horse-bean (*Vicia faba*) seedlings by dipping their roots in a solution for 1-48 hrs. After exposure, individual parts of the plant were ignited and intensity of the radioactivity of the ashes of different parts was measured by an electroscope. From this experiment they were able to conclude that lead was taken up and stored mainly in the roots. Leaves were found to have comparatively less amount of it. Since then isotopes have been variously used in tracing metabolic paths in plants. Some examples are given below:

Translocation. Using $^{14}CO_2$ feeding techniques, O. Biddulph and R. Cory (1965) could prove that the movement of solutes in the phloem elements is bidirectional. They observed that leaves nearest to the top transport metabolites primarily

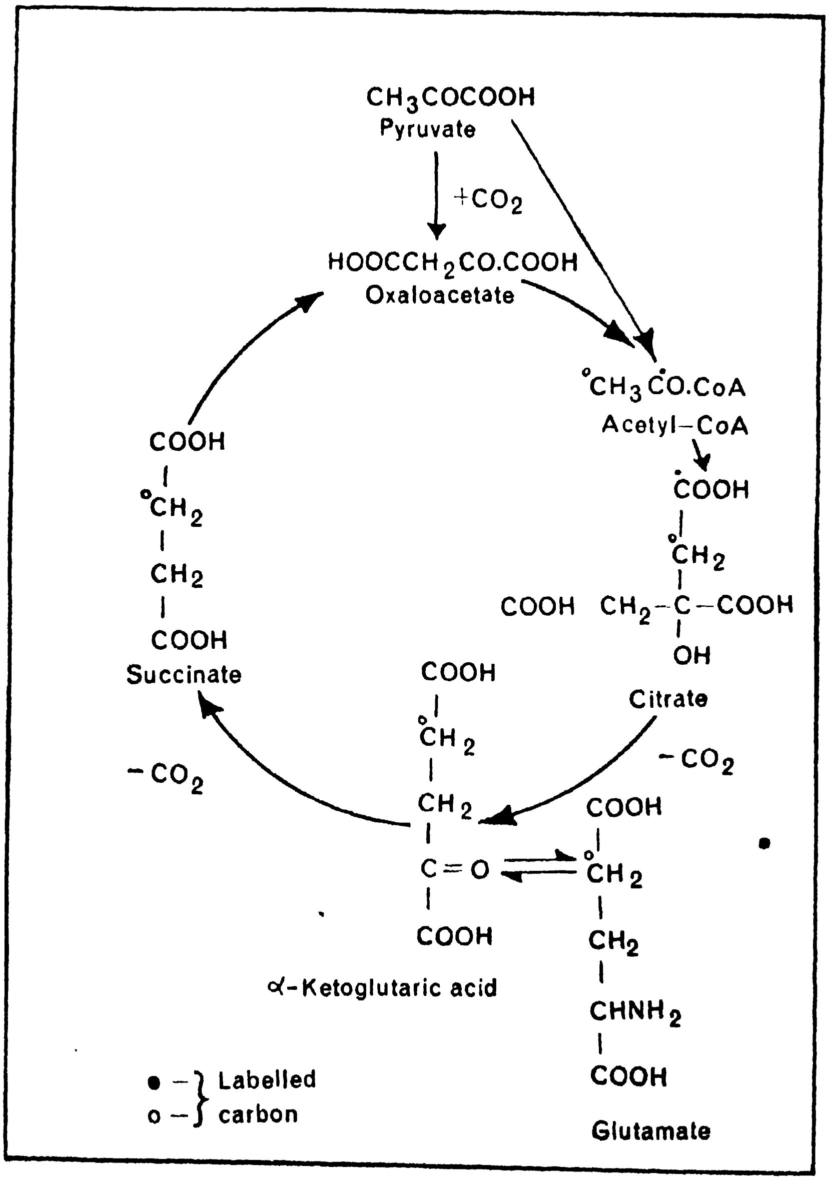

Fig. 2. The Krebs cycle

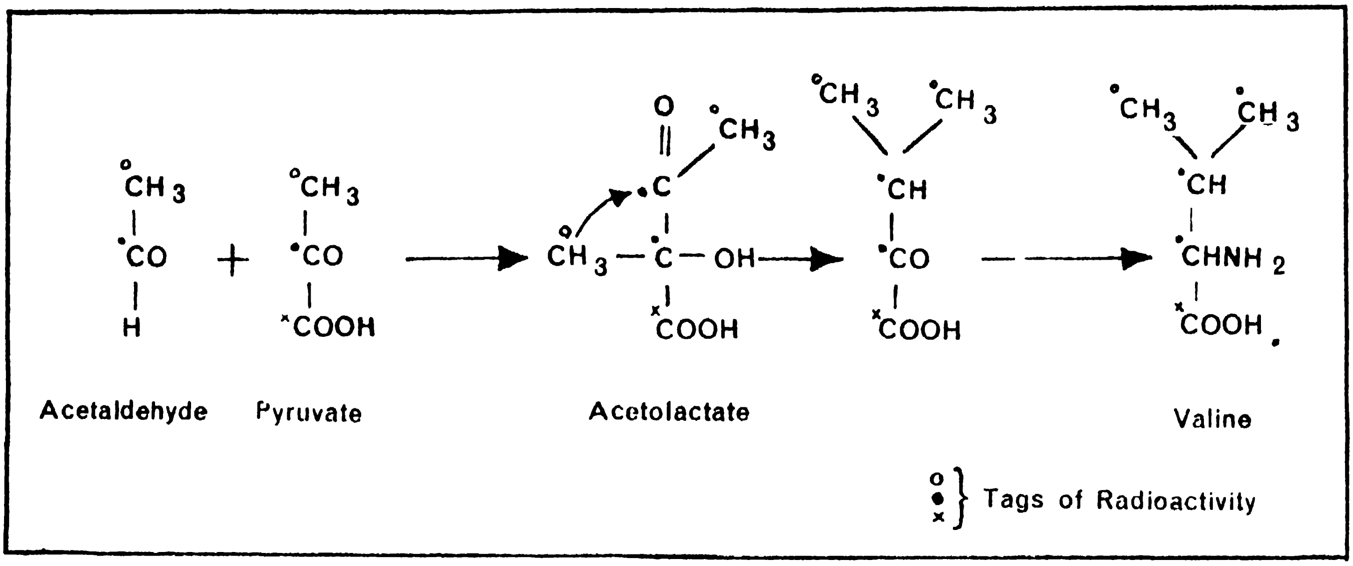

Fig. 3. Valine biosynthesis

to the stem apex, while those near the base transport them primarily to the roots. Those in the intermediate position, however, move metabolites in both directions.

K.W. Joy (1964) proved that a little tangential movement of solutes through phloem elements also takes place. He demonstrated that a plant exposed to $^{14}CO_2$ showed labelled metabolites only in leaves directly above the roots or in roots directly below the fed leaf. He could induce tangential movement by removing all the leaves of one side of a twig except a few immature leaves at the top and then feeding $^{14}CO_2$ to a mature leaf on the opposite side. Radioactive metabolites were found not only above and below but also in leaves on the other side (Fig. 1).

Nitrogen fixation. The insectivorous plants receive nitrogen from proteinaceous matter through their leaves. The other plants, however, have their nitrogen supply in the form of nitrates which are absorbed from the soil. The production of nitrate in the soil takes place through the agency of bacteria which are symbiotic to some plants. For example, *Bacterium radicicola* is capable of fixing atmospheric nitrogen in legume plants. There are also some free-living soil bacteria, e.g., *Azotobacter* which are able to utilize gaseous nitrogen.

The metabolic pathways of nitrogen fixation in *Azotobacter* have been studied by using ^{15}N as a tracer. It is found that if ^{15}N is used, it is rapidly incorporated into $^{15}NH_3$ which can be then expelled into the environment. Secondly, there is high accumulation of ^{15}N in glumatic acid suggesting that this amino acid is situated on the metabolic pathway of nitrogen fixation. Thirdly, the external supply of $^{15}NH_3$ results in similar condition of amino acid production (i.e., of glutamic acid) in bacteria and formation of nitrites or nitrates in the soil. Thus with tracer technique it has been possible to understand the nitrogen-fixation cycle.

Carbon pathway in photosynthesis. The first isotope used to replace non-radioactive carbon (^{12}C) in carbon pathway studies was ^{11}C. Its application met with limited success as the life time of the latter was too short for easy detection (half-life of ^{11}C is 20.5 seconds). Just before World War II, Martin Kamen and Sam Ruben at Berkeley, California, discovered another isotope ^{14}C (half-life 5,720 years). Its application has given spectacular results.

Conversion of CO_2 into carbohydrates with the help of reducing agents is the most thoroughly studied work in the field of photosynthesis. The various steps have been elucidated with the help of radioactive tracer carbon. This was done at California by Melvin Calvin, A.A. Benson and J. Bassham in 1961 which won them the Nobel prize. They experimented with a unicellular alga,*Chlorella*, and exposed it to $^{14}CO_2$ for different time periods. The plants were then killed and analysed. It was observed that phosphoglyceric acid (PGA), a 3-carbon compound, was the first photosynthetic product. Further studies revealed that the carbon at position 1 only was replaced by radioactive carbon. When $^{14}CO_2$ was added in the dark, the labelled PGA accumulated as it did not have the chance to be converted into sugars. During this process, however, the radioactivity of one of the compounds decreased due to the increase in PGA concentration. This compound was later identified as

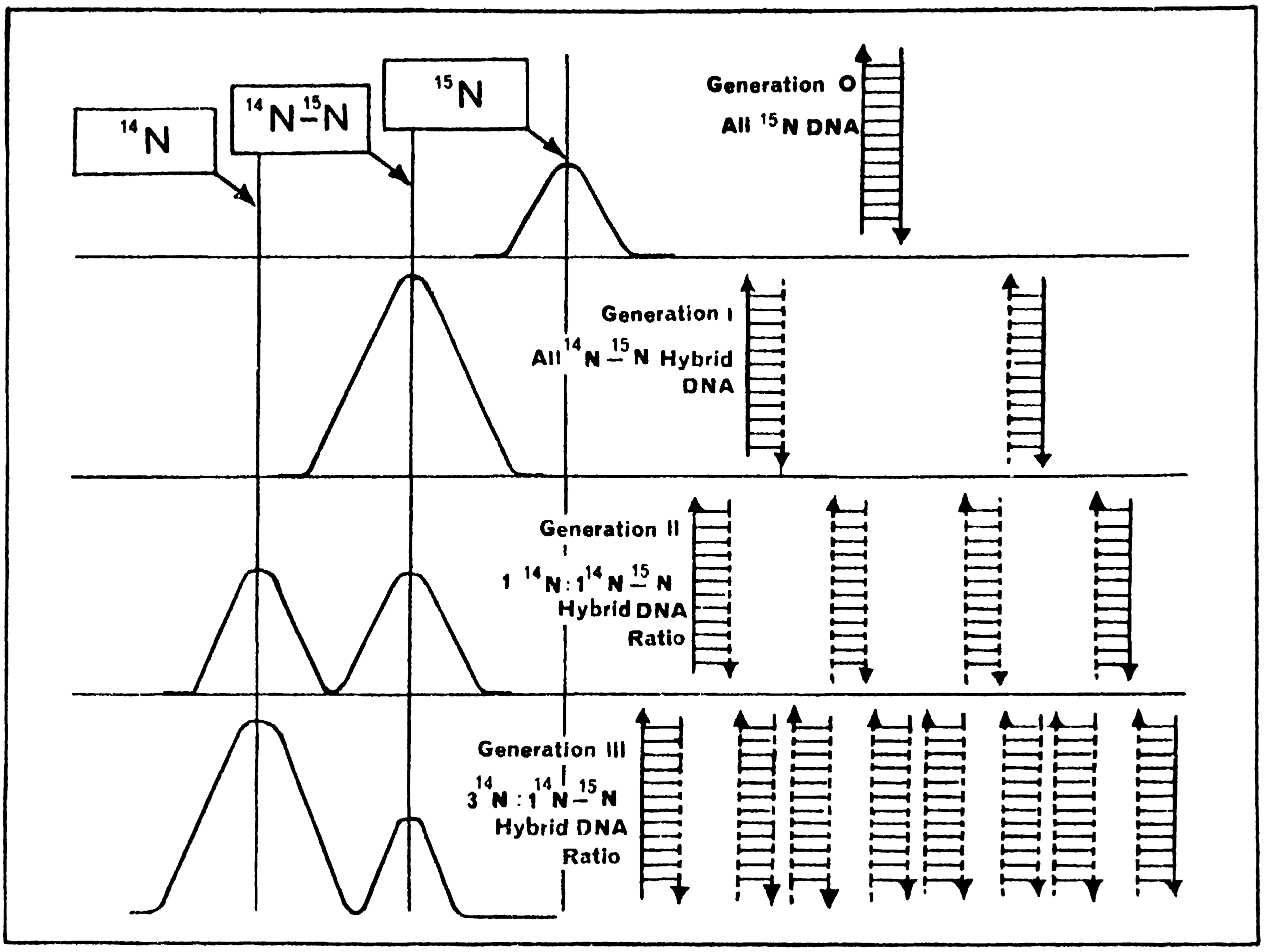

Fig. 4. Strand separation

ribulose diphosphate (RDP). It was only by using $^{14}CO_2$ that the progress through the intermediate stages of the cycle could be followed.

The Krebs cycle. This cycle is a chain of reactions in which chemical energy is made available to various metabolic processes and CO_2 released. It is actually a series of syntheses but without any net synthesis. Here a 2-carbon compound enters the cycle of reactions and two CO_2 molecules leave; no weight is gained and product formed. However, energy is produced as adenosine triphosphate (ATP) which accompanies CO_2 liberation.

Though this cycle was discovered without the help of isotopes, details of the processes particularly that of participation of acetic acid could be studied only with labelled compounds. Either carboxyl-labelled (CH_3C^*OOH) or methyl-labelled (C^*H_3COOH) acetic acid was usually incorporated in such experiments. Apart from this, some side chain reactions of the metabolic pool, e.g., synthesis of glutamic acid from α-ketoglutaric acid (a chief product of the Krebs cycle), aspartic acid from oxalocaeetic acid, and 'haeme' group of haemoglobin from succinic acid were also elaborated. The distribution of radioactive carbon amongst different products also indicated the priority of a reaction over others, as well as the rates at which the equilibria of different reactions were reached (Fig. 2). In some microorganisms it has been further confirmed that valine, an amino acid, is derived from pyruvate and that all carbon atoms of valine are donated by the latter (Fig. 3). This was possibe only by isotope incorporation and analysis of isotope distribution in the product from a single precursor-pyruvate labelled in three different positions.

Enzymatic reactions. Incorporation of labelled molecules into unlabelled compounds has served as a powerful tool in understanding the reversible enzymatic reactions. For example, it was possible to follow the carboxylation process of propionic acid by CO_2. This reaction is propelled by propionylcarboxylase in presence of ATP as the energy source. The experiments by M.D. Lane and his coworkers consisted of incubating the enzyme with ^{14}C propionyl CoA (as source of propionic acid). This did not lead to carboxylation. But when methylmalonyl CoA was incubated with the ^{14}C propionyl CoA, it resulted in the formation of radio-active methylmalonyl CoA. This could only be explained on the basis of the formation of enzyme substrate complex (enzyme CO_2 complex in this case).

A. Peterkofsky (1962) experimented on the same lines with the enzyme histidase, an enzyme that initiates irreversible reactions of histidine formation, and proved that this enzyme also forms an enzyme-substrate complex as an intermediate to complete the reaction.

Protein synthesis and transfer of genetic information

With the understanding that the living matter depends entirely on the working of the enzymes which act in close coordination to make possible the highly organised flow of chemical reactions, two major questions remained to be answered: (a) How are enzymes made? and (b) How is enzyme synthesis controlled? Both are now satisfactorily answered by molecular biology. It was S. Spiegelman who by radioisotope technique was able to discover that the enzymes (which are nothing but proteins) are synthesized from free amino acids and not from pre-existing proteins. Whole of the enzymatic machine was examined, taken apart into its components and then put together in the test-tube to make proteins. The entire venture came to success because of the use of radioactive amino acids.

DNA replication. The mechanism of DNA replication, as proposed by J.D. Watson and F.H.S. Crick (1953), is supported by a large number of experiments with bacteria, algae and other organisms. Such experiments also involved the use of isotopes. The commonly used isotope was ^{15}N, a heavier species of nitrogen. The molecules of DNA containing ^{15}N are denser and heavier and this difference in density could be detected by centrifugation.

Experiments using ^{15}N labelled DNA were carried out in 1958 by M. Meselson and F.W. Stahl, undergraduates at California Institute of Technology using *Escherichia coli* cells. The cells were grown for several generations on a medium in which the nitrogen was present as ^{15}N. The progeny cells had DNA fully labelled with ^{15}N. Such cells were then transferred to a medium that contained only ^{15}N as a nitrogen source.

If DNA replication involved strand separation, definite predictions could be made about the density of DNA molecules found after various growth intervals in a medium containing only ^{14}N. After one generation of growth, all the DNA molecules should contain one heavy (^{15}N and one light (^{14}N) strand and thus of intermediate hybrid density. Experiments showed exactly same compositions. Similarly, after two generations of growth, half the DNA molecules are light and half hybrid, just as strand separation predicts (Fig. 4).

Many more similar studies have helped us to understand biological problems by the use of isotope techniques. Examples are: identification of messenger RNA (S. Brenner *et al.* 1961), nucleic acid hybridization (S. Spiegelman), turnover of *m*RNA (C. Levinthal *et al.* 1962), assembly of amino acids (M.H. Dintzis, 1961), translation mechanism from *m*RNA to protein and DNA synthesis (A. Korenberg 1961). etc.

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GLUE AND GELATINE

M.D. RANGANAYAKI AND S. DIVAKARAN

Obtainable from animal slaughter wastes, uses of glue and gelatine range from plywood adhesives to pharmaceutical capsules

TO the common man glue means an adhesive that is available in the market. Though the word 'glue' is common to most adhesives, it specifically refers to cooked animal protein used for its adhesive property. The earliest records of its use are given by Pliny who wrote "Glue is cooked from the hides of bull." Glue and gelatine may be defined technically as the chief hydrolytic products of collagen present in bones and connective tissue of vertebrate animals. The distinction between glue and gelatine is one of purity; glue being impure gelatine. (*Gelatine* refers to the commercial or laboratory product which includes inorganic salt and other impurities. *Gelatin* refers to the derived protein only.) Glue is used for its adhesive property and gelatine for its cohesive or gelling property. Gelatine is extensively used in ice-cream jellies, marshmallows and several other food preparations and in its purest form finds use in the photographic industry. It is also used for capsule making in the pharmaceutical industry.

The raw materials for the manufacture of glue and gelatine are waste portions of animal skins and bones. India is rich in livestock and naturally offers an unlimited quantity of raw materials for its manufacture. Unfortunately, however, the exploitation of this industry is only now on the rise and we still import large quantities of high grade gelatine.

Raw materials

The most common raw materials in India are the trimmed ends of hides and skins obtained during their processing into leather. Bones from slaughter house and those collected from forest and grazing areas are also used for gelatine manufacture.

The object of commercial production is to manufacture a product of uniform quality and properties to suit the end uses. There are two methods of extraction of gelatine, namely, the 'acid conversion process' and the 'alkali conversion process.' Both aim at controlled hydrolysis of collagen to gelatine. The flow diagram (Fig. 1) gives the outline of the whole process.

The skins arrive at the tannery in a salted condition for being processed into leather. The trimmings (the frayed ends of skins) accumulate in a good amount when large stocks are handled. As the tanning process involves liming, addition of sulphides, deliming and tanning, trimmings are a mixed lot from all these stages. Tanned skins are unsuitable for gelatine manufacture though they may be useful for glue stock.

Alkali conversion process

When the trimmings arrive at a gelatine plant, they are subjected to a thorough washing to free them from adhering foreign material and soluble impurities such as salt, lime and sulphides. The washed stock is soaked in a saturated solution of lime (calcium hydroxide) for periods ranging from 15 to 45 days. Fresh lime is added frequently. The stock does not require much handling during this process.

During liming process, the trimmings become plump and lose a large part of the interfibrillary material, which is soluble in lime. Collagen is left for further processing. The limed stock is thoroughly washed and soaked in dilute acids such as hydrochloric acid to raise the acidity or to bring the pH of the stock to around 5.5–6.5 at which the extraction of gelatine is the maximum.

The acidified stock is transferred

Miss Ranganayaki is scientific assistant in the Central Leather Research Institute, Madras. Dr. Divakaran is scientist in the same Institute.

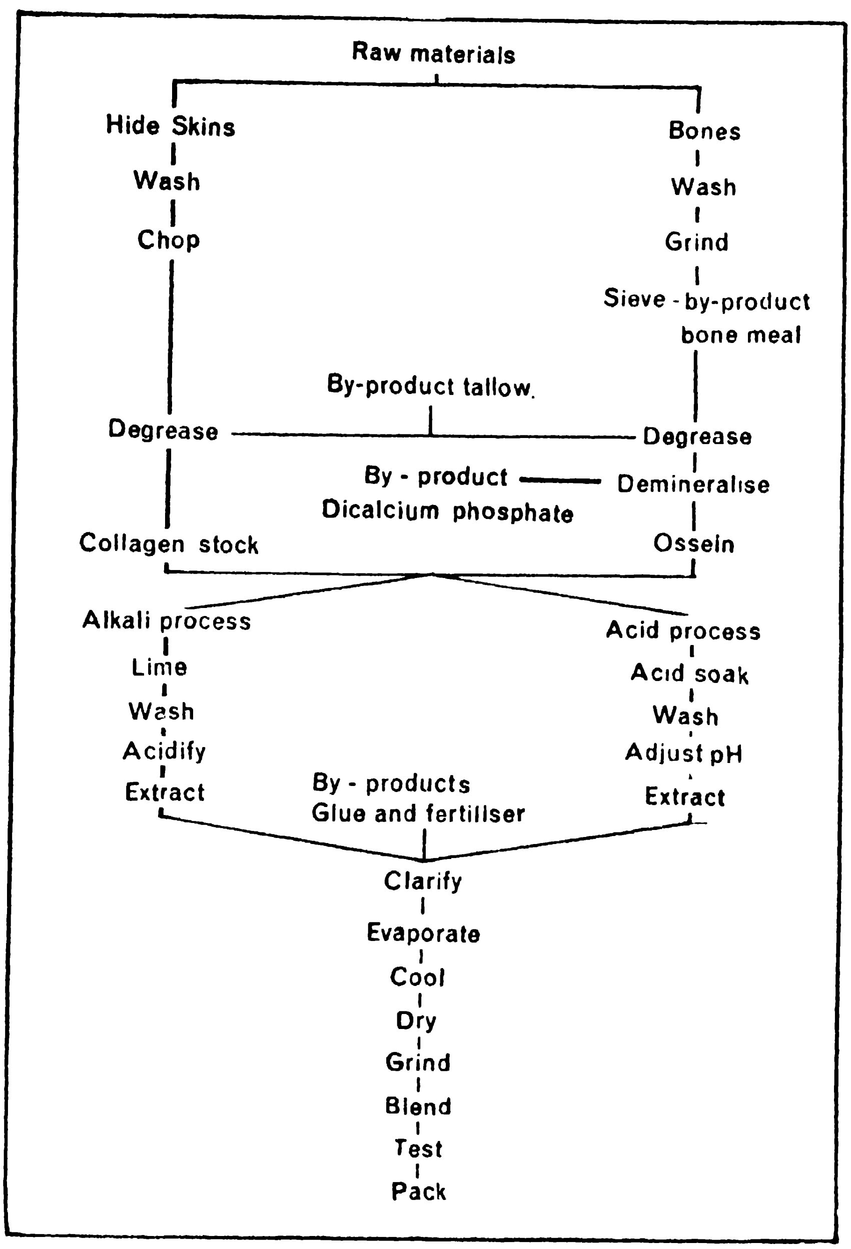

Fig. 1. Flow diagram of manufacture of gelatine

to cooking vessels and heated to 60°C. At this temperature the collagenous material undergoes thermal shrinkage and breaks down into gelatine. The extraction at this temperature is carried out from 2 hrs to as much as 8 hrs depending on the quantity handled. The liquid, which contains gelatine of the highest quality, is drained off and fresh water is added. Further cookings are carried out at 10°C intervals until boiling. The liquor is drained off at the end of each cooking.

Acid conversion process

This process is conventionally used for pig skins. However, other skins can also be extracted by this method.

After the skins are thoroughly washed they are soaked in a fairly concentrated solution of an inorganic acid (hydrochloric, sulphuric, sulphurous or phosphoric acid upto a maximum of 5 per cent strength) for a period ranging from 12 to 48 hours. The soaking causes the collagen to swell considerably. The acid supernatant is then discharged and the pH of the stock is raised to 4–5 by continuous water wash. .(The original pH of acid will be around 2.) At this stage the non-collagenous proteins are insoluble and so are not subjected to extraction by the subsequent process. The procedure for the extraction of gelatine is similar to the one described under 'alkali conversion process.'

Gelatine from bones

Bones which form the supporting skeletal framework of the body are hard structures made of a collagenous fibrous matrix with deposition of minerals, mainly calcium and phosphorus, and are similar in composition to rock phosphates. The mineral matrix offers rigidity to the skeletal framework. The collagen content of bone ranges from 12 to 18 per cent by weight. Other than minerals, bone also contains fats and other carbohydrate constituents called protein polysaccharides. The mineral part of the bone must be removed before gelatine can be extracted. Recently, however, methods for extraction of gelatine from bone without demineralisation have been developed.

Bones are first crushed in a bone mill to reduce them to a fairly uniform size of about 1 cm cubes and are washed free from extraneous material with water. Fats present in fresh bones can be extracted either by steaming or subjecting them to extraction by solvent after they have been dried. In old bones, the fat content is meagre because a major part of it had been exhausted by microbial action and also due to its conversion into soaps with the bone calcium, For demineralisation, the defatted bones are soaked in an acid solution containing 4–10 per cent of hydrochloric acid (or other acids such as sulphuric acid or sulphurous acid). The soaking is continued for periods ranging from a day to a few weeks depending on the quantity of stock, temperature of soak and concentration of acid. The acid is drained off for the recovery of dicalcium phosphate. The demineralised stock which is a spongy structure mostly constituted of collagen is known as ossein. The extraction of gelatine from ossein follows the same procedure as that described for trimmings.

Drying of gelatine

The extracted dilute solutions of gelatine cannot be subjected to the boiling temperature of water as they will coagulate and precipitate (denature). The extract cannot also be allowed to dry over long periods because, being a rich protein source, it will undergo spoilage by bacterial putrefaction. Thus, drying of gelatine is one of the important aspects in its manufacture.

As gelatine forms gel when cooled, it is formed in thin sheets and allowed to form gel by cooling. The cooled sheets of gel are quickly dried in a continuous current of hot air in a tunnel leaving sheets of dried gelatine.

Drum drying is a more common method used by most manufacturers for its simplicity and cheapness. Gelatine solution is continuously allowed to drip on the hot surface of a rotating drum and the dried product is scraped off continuously. Control of temperature is rather tedious yielding sometimes a charred or denatured product.

In 'beading', gelatine solution is allowed to fall into ice-cold solvents which are immiscible in water. Drops gellify and form bead-like structures. They are then dried in a gust of hot air. Spray drying of gelatine has been tried out, but the end product quickly becomes lumpy and forms inseparable cakes. Special spray driers with cooling systems for dried gelatine are available but they are too expensive. On a laboratory scale, gelatine solutions can be dried as thin films on polythene sheet under the draught of wind of a ceiling fan overnight.

In most of the above methods of drying, it is preferable to concentrate the liquor by using vacuum evaporations. This minimises denaturation and improves gelling prior to drying.

Glue is dried by pouring concentrated gel on a wire mesh where it is allowed to set and dry up in sun's heat. The end product emits a foul odour caused by putrefaction.

Properties of gelatine

High grade gelatine is a light yellow, semi-crystalline substance with no odour and no taste. It does not dissolve in cold water but if stored in open containers cakes up due to its hygroscopic nature. It swells to a considerable extent in cold water and dissolves slowly when warmed to form a viscous solution. On cooling, the solution makes a strong gel.

Granular gelatine has an average specific gravity of 1.3–1.4. Its solutions are optically active. The viscosity and gel strength of gelatine are the two main characteristics on which the quality of gelatine is assessed. The gel strength is measured usually in an apparatus called Bloom Gelometer. This apparatus determines the weight in grams required to depress a flat plunger (12.7 mm in diameter) to a distance of 4 mm into a jelly containing 6.67% gelatine. Gel strength is expressed in grams bloom.

Gelatine is insoluble in most of the common organic solvents. Being a protein its solutions resist changes in acidity and alkalinity due to its amphoteric property. This property is due to the presence of amino groups and carboxylic groups shared by the amino acids that constitute gelatine. These groups control ionisation and hence the solubility of gelatine in water. Acid-extracted gelatine is little ionised and is least soluble at pH 8. The alkali-extracted gelatine exhibits the same property at pH 4.8. The two are called the isoelectric points of gelatine which are important in achieving optimum extraction of the product from collagen.

Gelatine has a great affinity for water, in which it forms a colloidal solution. It is an effective emulsifier and a stabilizer of foam. As a protective colloid it finds wide use in photographic industry.

Uses

Commercial glue finds extensive use as an adhesive in plywood, veneer, cabinet cardboard, matches and many other industries. Commercial gelatine is used as printing rollers, sizing agents in textiles, in leather dressing and polishing, as foaming agents for clarification of wines and in ore floatation technique, to mention only a few. Edible gelatine though not a wholesome food is a valuable source of protein diet. It is eaten in the form of ice-cream jellies, cream foaming agents, soft chocolates, marsh-mallows and host of other edible products.

In pharmaceutical industry gelatine is used for making capsules for enclosing and protecting medicament. It is also used as an emulsion stabilizer and as a binder in tablet making.

Photographic industry is one of the largest users of gelatine. In the manufacture of films and papers it serves the multiple function of an adhesive, thin film, and as a protective colloid for halide ions. It also actively takes part in the chemical conversion process in image development. Photographic gelatine has to meet the most stringent requirement in quality and purity and should be particularly free from heavy metal ion impurities. Recent attempts to replace gelatine with synthetic polymers have not been very promising.

Modified gelatines are also used as a plasma expander in blood transfusion, in manufacture of surgical sponges, dusting powders and as thin films to protect wounds. The residue after extraction of gelatine is a valuable nitrogenous fertilizer. The acid used for demineralisation of bones dissolves the phosphates of bones which are converted into dicalcium phosphate, a valuable fertilizer. Tallow is a by-product obtained by degreasing of skins and bones and finds extensive use in soap and candle industry. The fine dust obtained in bone crushing mill is marketed as bone meal, a valuable stock feed and fertilizer.

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LETTERS

(*Continued from page 370*)

Nutri Nugget with 50% protein and a ready-to-eat snack called *Protesnac* with 15% protein (all soy-based). As such, a foreign food manufacturer need not have been cited as an example when aforesaid soy-based products are available in India.

P.A. VENKATESAN
New Delhi

Soy-milk

Sir, In the very informative article "Soybean—an ideal food" (*S.R.* June, 1974), it has been suggested that a cup of soy-milk with a teaspoon of honey taken every night is beneficial. I would like to know under what name the soy-milk is available in the market.

VISHVENDRA KUMAR
Patna Medical College
Patna

Naming the cyclones

Sir, Thank you very much for publishing the article " Cyclones: The terror of the tropics" (*S.R.* June, 1974). Nowadays much effort is being made to familiarise the significance of meteorology and proper utilization of Meteorological Department by the public. The effort of Sri Radha Kant Bharati in explaining tropical cyclones to the level of a common man is deeply appreciable. I would like to add the following.

The way tropical cyclones are named is often interesting and funny. In our country, usually they are named by the stations at which they cross the coast; Calcutta cyclone of 1894, or Bakerganj cyclone of 1876, for example.

In the northern Atlantic and Pacific Oceans all hurricanes and typhoons (as the cyclones are called in those regions) are given female names. "Santa Ana" which struck Puerto Rico with exceptional violence on July 26, 1825, and "San Felipe" which passed over Puerto Rico in 1876, are examples.

A forecaster in Australia named hurricanes in that region after political figures whom he disliked most!

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Andhra University, Waltair

SCIENCE SPECTRUM

Is metric time possible?

TIME is a basic concept that deals with the occurrence of events. The daily rotation of the earth on its axis provides the unit of time which is in everyday use, the mean solar day. Since the earth does not travel along its orbit at a uniform rate, the mean solar day is taken as the standard. It is the average throughout a year of the time between the successive transits of the sun across the meridian at any place.

The mean solar day is divided up into 24 hours, 24×60 minutes, and $24 \times 60 \times 60$ seconds. It is estimated that the earth is slowing down at the rate of three thousandths of a second a day. Thus the solar second based on Greenwich Mean Time (GMT) is not sufficiently accurate for several scientific purposes. Uniform time is obtained from atomic clocks which were standardised with GMT in the year 1900.

The fundamental unit of time is the second which has been redefined by the Thirteenth General Conference of Weights and Measures in 1967 as follows:

"The second is a duration of 9, 192, 631, 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the fundamental state of the atom of Cesium-133."

The modern trend is to establish standards in terms of atomic phenomenon, as such standards are indestructible and superior in precision, stability, reproducibility and accessibility. However, in everyday life, mean solar time is universally used for all practical purposes. The incovenience in the present sexagesimal system of time scale is two fold. Firstly, it involves computational problem. For example, if a man works from 9-45 A.M. to 3-30 P.M., the total working time cannot be calculated by simple subtraction. Similarly, it is not easy to tell instantly how many minutes or seconds make 11 hours, 39 minutes and 23 seconds. Secondly, in a 24-hour day, there are two sets of 12 hours, those from midnight to noon are called A.M., and those from noon to midnight are designated as P.M. Without proper use of A.M. or P.M., an event cannot be recorded without ambiguity. To avoid the irrationality and inconvenience of the present sexagesimal system, and to make use of a continuous reckoning of time, the introduction of a decimal time scale is proposed.

Historical background

It is strange that although metric units are widely used for weights and measures, there is no equivalent system for the measurement of time. The metric system was conceived and developed in the last part of the eighteenth century just after the French Revolution by a team of French scientists. The possibility of dividing time decimally was also considered at that time. The months were renamed and divided into ten-day interval; the days were divided into ten equal parts which were further subdivided decimally. A.D. and B.C. were replaced, and September 21, 1792 became the first day of the year of "1 Liberty." Curiously enough this calendar lasted for only twelve years in France, which then went back to the old system. One of the decimal clocks made by the then French technologists is still present in the collection of Smithsonian Institution in the U.S. National Museum, in Washington, D.C., which has both decimal and conventional dials.

The unpopularity of the decimal time may have been due to some historical reasons. Firstly, computation of time was less important then than it is now and its practical utility was not fully appreciated. Secondly, ten-day periods, instead of a week, eliminated Sundays and Saturdays, and thus would have hurt the Christian belief and dogmas.

During metric reform in the United States, just after the Second World War, there was a suggestion by Frank J. Moles to implement decimal time-scale. A sample clock was also constructed under his supervision, using decimal division of the day. Unfortunately there was a poor response. In the present highly scientific and technological age, a system of time scale having the simplicity, convenience and scientific interactions that the metric system possesses can no longer be denied a fair trial. The change-over to decimal system of time is necessary to avoid future hardships and complications.

Decimal time units

The possibilities of various types of decimal time systems have been considered for many years, and various schemes have been suggested from time to time. Of these the most logical and useful seems to be that

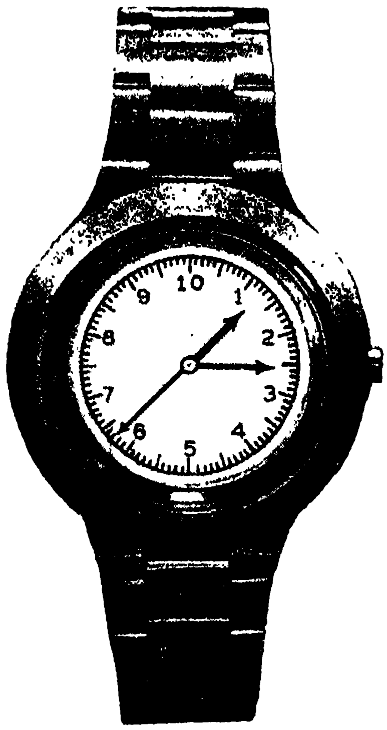


Fig. 1

based on the present mean solar day. In the present scheme, the day retains its original duration of time. For convenience and simplicity, day is divided into 10 metric hours (mh), and each metric hour into 100 metric minutes (mm), and each metric minute into 100 metric seconds (ms). Since decimalisation of time scale is really its metrication, the prefix 'metric' may be used in the new units to avoid confusion in the nomenclature. Millisecond is the thousandth part of a metric second. The connection between the two systems of units may be effected through a day, remembering that 1 solar day = 24 hours = 10 metric hours = 1000 metric minutes = 100,000 metric seconds. The duration of a metric second could possibly be matched with the vibration rate of some other atom, and may be precisely defined.

The arithmetic of conversion between the two systems of time scale is quite simple, but one has to decide to what extent one could round off a converted value. A simple conversion table is shown below:

1 mh = 2 4 h
1 mm = 1.44 m
1 ms = 0.864 s
1 h = 0.416 mh
1 m = 0.694 mm
1 s = 1.157 ms

Reckoning of metric time units

The Zero hour of the metric chronometer may be synchronised with the midnight. The day begins at midnight and runs through 10 metric hours. Thus 6 A.M. would be 2.50 in the metric chronometer, 12 noon would be 5 o'clock, 6 P.M. would be 7.50 and midnight would correspond to 10 o'clock. In the 10 metric hour notation, a decimal point may be put after metric hours, as a position index, when metric minutes and metric seconds are to be recorded alongside. The digital arrangement is shown below:

Digital arrangement		*Explanation*
0 mh	indicates	Midnight
2 mh	,,	2 mh past midnight.
2.24 mh	,,	2 mh and 24 mm past midnight
2.24 56 mh	,,	2 mh, 24 mm and 56 ms past midnight

The advantage of adopting a continuous reckoning of metric hours from 0 to 10 instead of using the subdivisions of A.M. and P.M. is obvious. The decimal system allows no uncertainty as to the epoch designated. No conversion problem arises within the system. It is only necessary to move the decimal point.

The dial of a metric chronometer is shown in Fig. 1. It would be convenient to use grades instead of degrees in marking the time intervals in the dial. Since 100 grades make a right angle, 4 grades displacement will indicate the time interval of a metric minute or metric second around a dial of 100 divisions. At the time of introduction of decimal system of time, existing chronometers can be re-adjusted, re-calibrated and re-designed. The hour hands of the present day chronometers execute two revolutions during a full day (24-hour period), whereas that of a metric chronometer would complete only a single cycle driung the same period. The change-over to the new system involves a change in the dimensions and count of the gear tooth. In essence, a thirty-six tooth gear is fastened on the 1 RPM shaft of a synchronous clock having 25-tooth gear, and hand moving around a dial with 100 divisions. Each of these divisions then represents 1 metric second. The shaft is then geared through a 100 to 1 gear train

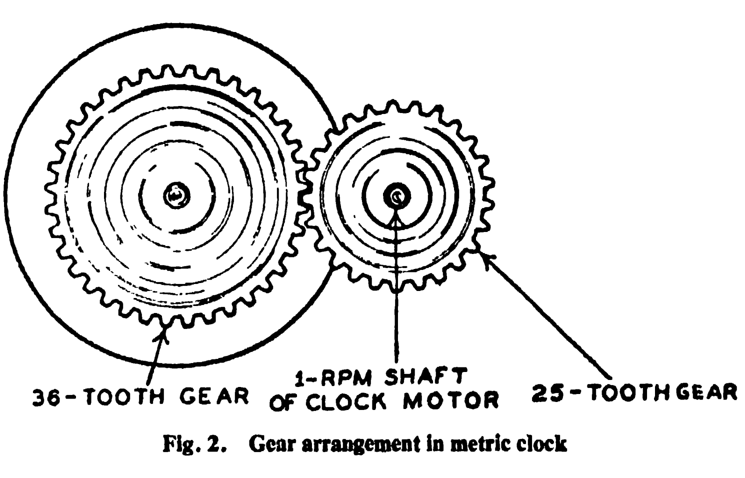


Fig. 2. Gear arrangement in metric clock

to another hand moving over a 100 divisions dial. These divisions represent one metric minute. Then the shaft of this hand is connected through a ten to one gear train to a hand on a dial with ten divisions. Each of these divisions then represents 1 metric hour.

Time has come to carry the decimal system to its full practical use. The decimal time may be revived to link with the decimal coinage and metric weights and measures. The reintroduction of Centesimal division of angle is an interesting possibility. Instead of using clumsy $90^\circ-60'-60''$ system, $100^G-100'-100''$ can be used. Trigonometric tables can be revised accordingly. Moreover if latitudes and longitudes were measured in this system, then the decimal time and decimal longitudes could be matched easily.

There will no doubt be slight inconvenience to begin with the new time scale, but this will not last. The justification for adopting the decimal system of time is that it introduces simplicity and convenience, and will make life easier. The detailed programme of adoption and implementation of metric time could be drawn by an international body, say OIML (International Organisation for Legal Metrology). The Indian Standards Institution (ISI) has played a leading role in reforming the metric system of weights and measures, and decimal coinages in India. In this context, ISI can offer valuable suggestions. The most essential condition of success would be a climate of opinion in favour of this reform. Full publicity should be given to the advantage of the decimal system of time scale, and an international approach to collective action should be called for.

SHANKER CHATTERJEE

Preserve the books longer

PAPER is essentially a mat of fibres. The properties of paper are determined by complex interaction of individual fibre properties and by nature and extent of bonding between the fibres. The basic factors which determine the strength of paper are fibre dimension, fibre strength, bond area, bonding strength per-unit bond area, distribution of bonds, fibre conformability and stress distribution. These factors are influenced by chemical composition and mechanical treatment. The most important chemical factor which determines the permanence of a paper is its acid content. Alum, which is added in the pulp during the rosin sizing, makes the paper acidic and is the cause of subsequent hydrolysis of the cellulose fibres.

Deacidification of acidic paper has, therefore, become a necessity for the preservation of books. The process of deacidification was developed in 1939-40. It consists of soaking acidic sheets in a bath of calcium hydrooxide solution (lime water) for twenty minutes and then in calcium bicarbonate solution for another twenty minutes. Neutralization by this process is complete and the paper attains a pH of 8.5 (i.e., alkaline).

Soaking of paper is very effective because the alkali reaches the innermost fibres. The only disadvantage is that the book requiring treatment has to be opened completely, treated, reinforced and rebound. A study of acidity in some of the old and rare books and their deacidification by spraying calcium hydroxide and cal-

Table 1

Sl. No.	*Date of Publication*	*pH Original*	*pH After treatment with $Ca(OH)_2$*	*pH After treatment with $Ca(OH)_2 + Ca(HCO_3)_2$*
1.	1708	5.0	9.0	8.5
2.	1711	4.7	8.2	7.8
3.	1716	4.0	8.5	8.1
4.	1730	4.1	8.5	7.9
5.	1744	5.2	8.4	7.8
6.	1788	4.6	8.2	7.8
7.	1795	3.9	7.9	7.6
8.	1803	4.4	8.2	7.3
9.	1809-11	4.4	7.4	7.2
10.	1821	4.8	7.6	7.3
11.	1824	5.3	8.1	7.8
12.	1825	3.4	8.6	7.6
13.	1826	6.2	7.8	7.2
14.	1842	4.4	7.8	7.4
15.	1854	4.8	8.6	7.6
16.	1867	5.5	8.4	7.6
17.	1872	5.6	9.0	8.0
18.	1872	6.8	8.2	7.4
19.	1881	4.5	8.4	7.6
	Average	4.8	8.3	7.6

cium bicarbonate solutions was done by the author in the laboratory of The National Library of India, Calcutta. The results obtained are shown in Table I.

The earliest book tested was of A.D., 1708 i.e., 266 years old and the latest was of A.D., 1881, i.e., 93 years old. Most of the samples except the two at S. No. 13 and 18 were in unusable and brittle conditions. The pH determination was made by cold extraction process in all the three steps. The deacidification was done by spraying the solutions with a hand-spray pump. Non-printed areas were selected for determination of pH. The treated samples were allowed to dry completely before determination of pH. (The sheets under test were in loose form and were treated flat and dried in air at room temperature.) Calcium hydroxide solution was prepared by adding 1½ gm of calcium oxide in 100 ml of distilled water. Saturated solution of calcium bicarbonate was prepared by passing carbon dioxide in a suspension of calcium carbonate in distilled water.

The purpose of neutralization of acidity of the paper is to introduce a protective calcium carbonate layer on the paper. Though the soaking method of de-acidification is the best one, spraying method is also quite useful as it can be done on a bound volume. If the deacidified books are kept slightly opened overnight to stop faster drying, the permeation of the alkaline solution is more thorough and the results are better. The difficulty, however, arises in judging the amount of spray required for a sheet. Experience enables one to know the quantity for different types of papers. The process is quite fast and one worker can deacidify about 1000 sheets per day with a motorized sprayer. The speed with a hand sprayer is however low.

Spray method of deacidification has an edge over the soaking method in that it can be adopted even in case of inks affected by water. If any document is written on one side with a water-soluble ink, the latter can be protected from washing away with a transparent lacquer and the paper can be deacidified by spraying from the plain side. Maps also can be deacidified by spraying from the plain side.

The spray method besides being simple is quite cheap. Average useful life of a non-fiction book (size 6″× 10″—pages 400) is about 10 years under usual storage conditions in Indian libraries, and its cost is Rs. 15/- on an average. It means that a new book will be required after 10 years, i.e., there is an average depreciation of Rs. 1.50 per year on the original cost. Cost of spraying and deacidifying one such book will no be more than 50 Paise at a time and one single treatment will be sufficient for about 5 years. It has been demonstrated that untreated acidic (pH 5-5.9) samples at a later stage of their lives lose 70 to 80% of their folding strength every four days. Samples of the same paper when deacidified and subjected to the same amount of aging require 24 days to reach 70 to 80% loss in folding strength. Thus it can very well be argued that the deacidification enhances the life of a book by about six times at a very nominal cost.

AVINASHI LAL

Antioxidants in food industry

CERTAIN food constituents such as fats, oils and oily flavour compounds become rancid when exposed to excessive air. As the name implies, antioxidants are substances which prevent or greatly retard the oxidation of easily oxidizable materials such as fats.

The antioxygenic action of antioxidants can be best explained by chain reaction theory. According to this theory, the molecules in an autoxidisable material, capable of reacting with oxygen, consist at any instant of a limited number that have been activated by the absorption of energy. When reaction occurs, activating energy of these molecules is released and can be absorbed by another molecule of the oxidisable material. Thus the limited amount of energy will set up a chain reaction and may lead to the oxidation of large amount of material unless the chain is broken by absorption of the activating energy in a side reaction. Antioxidants interrupt the chain propagation mechanism, that is, it is capable of receiving but not of passing on the activating energy. In the process antioxidant is oxidised and gradually destroyed.

Synergists, on the other hand, are substances which have little or no activity alone but which enhance the antioxygenic action of antioxidants.

Certain restrictions are imposed on the use of food antioxidants because they are incorporated into food products meant for human consumption. Thus an antioxidant should possess the following characteristics:

(a) The compound and oxidation product should be non-toxic;

(b) It should be easily incorporated into the foodstuff and should not impart any foreign flavour, odour or colour to the food even after prolonged storage;

Table 1

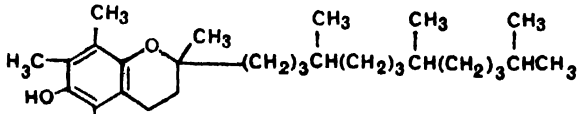
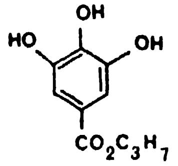
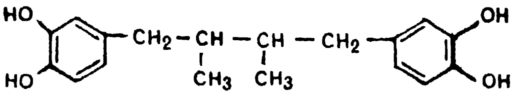
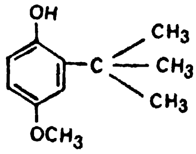
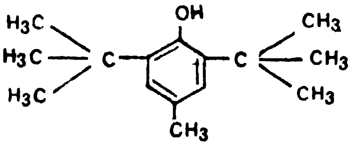
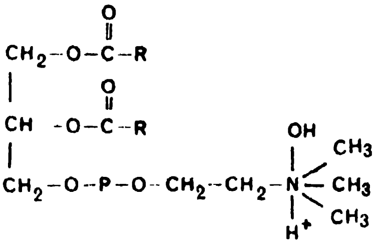
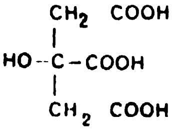
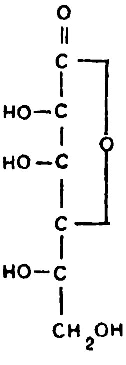
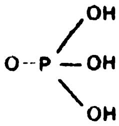
Antioxidant	Structure	Permitted maximum concentration
1. α-Tocopherol		0.01 - 0.03
2. Propyl gallate		0.01
3. Nordihydroguairetic acid (NDGA)		0.01
4. Butylated hydroxyanisole (BHA)		0.02
5. Butylated hydroxytoluene (BHT)		0.02
6. Lecithin (phospholipid)	 $\begin{array}{l} CH_2-O-\overset{O}{\overset{\|}{C}}-R \\ \vert \\ CH\ -O-\overset{O}{\overset{\|}{C}}-R \\ \vert \\ CH_2-O-P-O-CH_2-CH_2-\underset{H^+}{\overset{OH}{N}}(CH_3)_3 \end{array}$	some
7. Citric acid	 $\begin{array}{l} CH_2\ COOH \\ \vert \\ HO-C-COOH \\ \vert \\ CH_2\ COOH \end{array}$	some
8. Ascorbic acid	 $\begin{array}{l} O \\ \| \\ C \\ \vert \\ HO-C \\ \vert \\ HO-C \\ \vert \\ C \\ \vert \\ HO-C \\ \vert \\ CH_2OH \end{array}$	some
9. Phosphoric acids	 $O-P(OH)_3$	0.005 - 0.01

Table 2. Antioxidants for specific food items

	Food item	Antioxidant
1.	Dry fat	Oat extract, citric acid or tartaric acid
2.	Chicken fat	Mixture of BHA, propyl gallate, citric acid
3.	Ghee	Wheat germ oil
4.	Meats	Certain spices, mixture of NDGA, BHA and ascorbic acid
5.	Fish	Smoking, or a mixture of BHA and BHT
6.	Baked foods	Mixture of BHT and BHA
7.	Fried foods (applied in the form of antioxidant coated salt)	Mixture of BHA, propyl gallate and citric acid or NDGA and citric acid
8.	Milk powder	Ethyl gallate; NDGA
9.	Ice cream mixes	Vanila
10.	Wrappers and cartons	Mixture of BHA and BHT

(c) It should be easily available and cheap so that its addition does not increase the price of the food product; and

(d) It should be active at low concentrations.

Antioxidants in food were known and used long before their function was appreciated. Synthetic antioxidants commonly used in food industry are listed in Table 1. Several vegetable oils such as palm oil, soybean oil, rice oil, peanut oil, olive oil, cottonseed oil, sesame oil, coffee oil, etc., have been used to improve the stability of animal fats. Several spices remove unpleasant tastes and odours by preventing peroxide development and thus increase the stability of fats toward oxidation. Flours of several grains, condiments and flavourings have also been found to possess antioxygenic properties.

No single compound is equally effective in all substrates under all conditions. Table 2 lists some of the antioxidants used for specific food items. The most commonly used antioxidants are propyl gallate and NDGA; the latter is preferred because of its lower cost and slightly higher solubility in fats. However, they are ineffective under alkaline conditions, where BHT and BHA are used. A mixture of BHT and BHA is slightly synergistic and gives better results. Citric acid appears to be the most commonly used synergist. Commercially available antioxidants are sold in the form of mixtures, prepared specifically for the product in which they are to be used. A mixture of propyl gallate-BHA-citric acid is the most common.

Incorporation of small amounts of antioxidants in large amounts of food may cause mixing difficulties and thus can damage the texture or appearance of the food. This can be minimized by the use of diluents in which the antioxidant can be dissolved or uniformly dispersed. Propylene glycol is the most widely used diluent or carrier. Some antioxidants (e.g., BHT) are completely insoluble in propylene glycol and in that case some other diluent such as fat or fat derivatives should be used.

Addition of antioxidant to fats does not require diluent. In liquid foods, fine antioxidant powder or a dispersion in liquid carrier is added. The carrier solvent, if needed, can be removed by evaporation. In dehydrated products antioxidant is often added before the drying process. Food materials such as meat, fish or nuts are treated by spraying antioxidant suspension over them.

PURNENDU GHOSH
VINOD BIHARI
REETA BOSE

A look through L S D

LSD-25 (Lysergic Acid Diethylamide) was synthesized at the Sandoz Research Laboratories in Basle, Switzerland by Stoll and Hofmann in 1938, but it was not till 1943 that Albert Hofmann accidentally discovered its peculiar mental effects and hallucinogenic properties and set off a train of events, culminating in world-wide interest in the actions of this drug. LSD is now an important member of a growing class of drugs, defined as "psychodysleptic drugs which assert a confusional or disorganizing effect upon mental processes of behaviour and mimic acute psychotic disturbances". As a matter of fact in the early 1950's the term "psychotomimetic", i.e., psychosis-mimicking was generally used for this class of drugs. Humphrey Osmond in 1957 gave it the name psychedelic which means 'mind-opening' or 'mind-manifesting'.

Chemistry

LSD-25 is a colourless, semi-synthetic compound, the lysergic acid portion of which is a natural product of the ergot fungus *Claviceps purpurea,* which grows on rye and certain higher plants. The diethylamide part of it is structurally related to the uterine stimulant ergonovine, which is an isopropanol amide. A molecule of LSD contains an indole nucleus, separated from a nitrogen by two carbon atoms. This bears a structural similarity to the naturally occurring brain neuro-humour serotonin, which is implicated in a number of heuristic hypotheses linking brain-function to its chemistry. Dextro-rotatory LSD-25, is the only stereo-isomer which is pharmacologically active. This means, there is a high selectivity at the site of action of LSD in the brain. In addition to psychic functions, it effects somatomotor functions and those subserved by the autonomic nervous system.

Pharmacological properties

LSD is a powerful antagonist of the amine, 5-HT (5-hydroxy tryptamine, serotonin) and can also mimic its action. This serotonin-antagonism, as it is called, is a unique pharmacological property of LSD.

One of the most striking pharmacological characteristics of LSD is its potency. The average dose being 100 micrograms, an ounce would send 300,000 adults on a trip. The effective oral dose in normal human beings is as small as 0.5 to 1 μg/kg, which makes LSD 3000 to 5000 times more potent than other hallucinogens in producing similar psychic changes. Although as much as 2 to 2.5 μg/kg are taken by human beings, the amounts that are found in brain represent at most only 1% of the dose taken. This fact points to the extreme sensitivity of some critical brain receptors for the drug. LSD is well-absorbed by the gastro-intestinal mucosa after oral administration and although considerable amounts of LSD become bound to blood protein, the drug is nevertheless rapidly distributed to the body tissues, the highest concentrations appearing in the lung, liver, kidney and brain. A very high proportion of the dose is found in the bile, which is probably the preferred route of excretion.

After intravenous administration, highest amounts of LSD are found in the pituitary and pineal glands, and to a less extent in the hippocampus, amygdala, fornix and septal region, the thalamus and the hypothalamus. While LSD has dramatic effects on visual mechanism the drug concentrates not so much in the visual cortex but in the visual reflex centres. Another striking feature in the pharmacology of LSD is the rapid development of tolerance, so that after a few days of repeated use, a previously effective dose no longer produces a response. The uptake and clearance of LSD by the brain are critically related to the effects noted on levels and sub-cellular distribution of 5-HT. During the period of change in 5-HT levels, there is also a decrease in the levels of another brain neuro-humour norepinephrine, which is thought to be related to the excitation produced by LSD. Except for the rabbit, which is extraordinarily sensitive to LSD, the acute toxicity of this drug is not considered remarkably high. Acute LSD poisoning is devoid of any specific features, but death in all species results from respiratory failure.

Neurophysiological actions

Despite the wealth of data on this subject, a coherent and generally acceptable picture of the manner in which LSD exerts its effects on higher nervous functions remains obscure. That the prominent visual disturbances induced by LSD reflect varying degrees of alterations in the functional activity of elements in the visual pathway, is well established. LSD-induced blockade or activation of one or another synaptic site can lead to profound disorganisation of the temporal and spatial patterns of impulse activity.

It has also been recently brought to light that LSD may cause genetic defects. The geneticist Maimon J. Cohen and his colleagues have found chromosomal damage in a preliminary study of a small number of persons who had used LSD. A large number of cases of hospitalization for LSD—induced acute psychoses or with chronic schizophrenia or schizoid personality aggravated by the ingestion of LSD have been reported. Some of the patients suffered from "profound terror" others exhibited uncontrolled violence and a few attempted homicide or suicide.

Ingestion of LSD is followed after some time by unpleasant symptoms—nausea, vomiting, headache, chills, tingling, sweating and a variety of other sensations. Pupillary dilatation always occurs, and tremor and dry mouth are common. Some degree of insomnia the night after taking LSD is almost inevitable. Change in mood is the first characteristically evident change in behaviour. A drugged subject particularly in a socially facilitating situation, usually becomes extremely emotional with uncontrollable laughing or crying. A mildly humourous remark or one that is not ordinarily humourous may set off gales of laughter or torrents of tears. Belligerency may be sometimes invoked and communication becomes impossible. Subjects assume unusual postures—slouching on chairs, or lying on the floor.

Perceptual changes particularly distortions and hallucinations in the visual sphere are very common. Tactile sensibility is universally affected. Hallucinations, the report of perception of objects formed that nobody else can perceive are the most dramatic symptoms. Auditory hallucinations are less frequent than visual ones indicating an important difference between LSD-induced psychoses and naturally occurring ones such as schizophrenia, where patients are more prone to hear voices than to have visual aberrations. The ingestion of LSD by and large impairs intellectual processes resulting in confusion in appropriateness of action and difficulty in thinking. On the other hand, it has been claimed that this extraordinary state sometimes inspires production of unusual works of art or poetry. Facilitation of creativity is one of the arguments used for encouraging widespread use of these psychotogens.

Astonishing alterations in temperamental attitudes have been felt and observed in users. LSD research on animals revealed that the carp, a fish which ordinarily lies in the depths became a surface swimmer. Under the same drug spiders constructed a more perfect web, while a tomcat noted for his aggression cowered before an untreated mouse. Acid-heads (as LSD users are called) talk of the eternal present, for they experience an alteration in time-perception, loss of identity and what more, an interchange of sensory perceptions, i.e., colours are heard, music can be scented.

A challenge

This drug is indeed socially disruptive as the user's intellectual and visual functioning is impaired and this is often unknown to him. Quite recently a man on LSD trip killed his mistress imagining her to be a snake he was fighting in the bowels of earth. Timothy Leary, a psychologist from Harvard University, has claimed an intensified sexual experience for LSD, but for those for whom there is no genuine love or involvement, instead of an ecstasy of union, only isolation may result.

Likewise, drugs do not instil creativity. That gift must be present there already. They can at most heighten and augment it. The user can achieve a greater self-realization but it is arguable that any chemically induced state of being is unnatural and therefore any experience realised is fundamentally unauthentic.

Any analysis of LSD will therefore have to be a tripartite study of the biology of LSD, the relationship of LSD to the individual and to society reflecting our understanding of an important social concern. LSD and other hard-drug abuse is a severe national problem, rooted deep in the fabric of our lives, providing a challenge to every level of our society. It is a great challenge to medicine which must treat those who have been severely injured by uncontrolled use of the drug and at the same time must strive for research so that the full potential of the drug may become known and realised.

A.S. BALASUBRAMANIAN

How drugs penetrate gastro-intestinal barrier

THE therapeutic and pharmacologic efficacy of any drug depends on its suitable concentration at the site of action. When drugs are administered orally, their efficacy depends mainly on the absorption, i.e., the penetration of the drug through gastrointestinal epithelium. Thus it is important to know the mechanism of drug absorption.

As early as 1902, E. Overton (*Pfuegers Arch Ges Physiol,* **92**: 115), found that lipid-soluble substances easily and readily crossed the biological membrane. In order to explain this behaviour, he suggested that biological membranes are lipoidal in character. Later on, to explain the rapid transport of low molecular weight lipid-insoluble substances like urea and water, R. Collander and H. Birlaund in 1933 (*Acta Botan Fennia,* **11**,1) modified Overton's concept by proposing that lipid barrier is interrupted with aqueous channels or pores. Moreover, certain dietary constituents, such as, sugars, amino acids, certain vitamins, etc., are found to be transported through the barrier against a concentration gradient. It appears, therefore, that certain constituents of the barrier take an active role in the transport process. These barrier constituents are termed "Carriers". It has been suggested that cellular constituents like pyridoxal and certain phosphorus containing compounds act as carriers.

Nowadays, the biological barrier is thought to be a bimolecular layer of lipids with an inner and outer layer of protein or mucoprotein containing carriers and interrupted with aqueous pores and in a state of dynamic equilibrium with its surroundings.

Passive diffusion. By the term transport across a membrane we mean the translocation of the solute through a barrier interposed between the two phases, appearing in the same state in both phases.

Absorption of almost all the drugs or substances foreign to the body can be explained in terms of passive or simple diffusion across a lipoid barrier. In passive diffusion, the physico-chemical properties of the drug and the membrane control the transport process. The concentration gradient of the solute is the force required for movement.

Most drugs are either weak acids or weak bases. The extent of their absorption is dependent on the availability of their unionized moiety, since gastrointestinal barrier is permeable to the neutral lipid soluble substances. The availability of the unionized drug moiety is solely dependent on their dissociation constant (pka) and hydrogen ion concentration (pH) of the surrounding medium of the drug. Therefore, pka of the drug and pH of the gastrointestinal contents largely determine the gastrointestinal absorption of the drug.

Actually it has been found that weak acidic drugs are better transported in the stomach (acidic pH) and weak basic drugs in the intestine where the pH tends towards alkalinity. The theory works well for many drugs. According to this theory, the membrane should be impermeable to the ionized drug moieties. Evidence, however, suggests that the case is not so simple. It has been found that certain drugs, like quaternary ammonium compounds, tetracyclines, etc., are transported in their ionic form quite rapidly. So, one can generalise that though the concept of passive diffusion explains the absorption behaviour of many drugs, certain specialised transport mechanisms might also be operating.

Active transport. A drug is said to be absorbed actively when it obeys the following criteria: (1) The drug molecule must travel from a region of lower to higher concentration, (2) The Transport mechanism becomes saturated at a very high solute concentration, (3) The process shows specificity for a particular type of chemical structure, (4) If two substances are transported via the same mechanism, both will competitively inhibit absorption of the other, and (5) Substances which interfere with cellular energy production will noncompetitively inhibit the transport mechanism.

The active trasnport system more or less resembles the enzyme-mediated reactions. Like enzyme-substrate complex, the drug molecules also combine with the carriers. The complex is transported out of the gastrointestinal tract where the complex breaks off and the drug molecules are set free.

The active transport mechanism has been well documented in the absorption of ions, sugars, pyrimidines, amino acids and some vitamins; the matter is still inconclusive in the case of substances foreign to the body. It has been suggested that at least for substances which resemble the natural body constituents structurally, the active transport mechanism may be a possible one. Actually it has been shwon by some workers that certain serine and threonine derivatives of nitrogen mustard and antineoplastic agents, like derivatives of uracil and thymine, are able to cross the intestinal barrier against concentration gradients by processes that transport the parent amino acids and pyrimidines.

Though no firm demonstration of the active transport mechanism has so far been presented in the case of drugs, one cannot eliminate the possibility of the active transport system as a mechanism of drug absorption. Studies have to be carried out with compounds of wide structural variation before a final conclusion can be arrived at.

Facilitated diffusion. As a mechanism of drug transport it is relatively a new concept and has been put forward in order to explain the anomalous absorption behaviour of certain compounds which cannot be explained by conventional passive diffusion or active transport mechanism.

The criteria for facilitated diffusion are similar to active transport except that the drug molecule is not absorbed against a concentration gradient and the process does not require any further expenditure of energy as in passive diffusion.

It is believed that the drug molecules combine with carriers as in active transport process and the complex is transported likewise. The reaction between the carriers and drug molecules is a simple, reversible chemisorption requiring no energy. Since the transfer system does not modify the permeant, the interaction involves only hydrogen, hydrophobic and/or electrostatic bond.

Now coming to the question of the involvement of this mechanism in drug absorption, we find that absorption characteristics of certain drug molecules, such as, quaternary ammonium compounds, tetracyclines, etc., do not follow the usual passive diffusion. Moreover, enhancement of absorption of compounds in the presence of phosphatidopeptide fraction, suggests a possible carrier-mediated transport and strengthens the view that facilitated diffusion might be a mechanism for certain compounds. However, the matter is still inconclusive, much more data is required to show that this mechanism may operate for drug absorption.

Pinocytosis. This involves a process in which the cell invaginates and engulfs the substances being absorbed. The process is usually classified as an active transport because of its energy requirement and certain degree of specificity. Pinocytosis as a mechanism of drug absoption is still uncertain and probably has a small role because of its very slow nature.

On the evidences that have been presented uptil now, passive diffusion seems to be the most likely explanation of the absorption behaviour of many drugs. However, occurrence of active transport and facilitated diffusion are also known.

KALYAN CHAKRABARTI

NEWS & NOTES

Dr. Patel elected to the U.S. National Academy of Sciences

INDIA-born laser scientist Dr. Chandra K. Naranbhai Patel, Director of the Electronics Research Laboratory of Bell Telephone Laboratories at Holmdel, New Jersey, U.S.A., has recently been elected as member of the U.S. National Academy of Sciences. Dr. Patel is the youngest to be elected to the Academy since its establishment in 1863 to promote science and its uses for the general welfare. The Academy also acts as an official adviser to the U.S. Government on matters of sciences and technology.

Born on July 2, 1938 at Baramati in India, young Patel was educated in the College of Engineering at Poona (1958). He came to the U.S.A. in 1958 and received his M.S. degree from the Stanford University in 1959 and Ph.D. degree in electrical engineering from the same university in 1961. He joined the Bell Telephone Laboratories in 1961 as a member of its technical staff (1961-1967), becoming head of infrared physics and electronics research department (1967-70) and director of the Electronics Reseach Laboratory since 1970. Best known for his inventions in gas (carbon dioxide) lasers, particularly molecular lasers in infrared, and in pollution detection, Dr. Patel received numerous awards and prizes including Optical Society of America's Adolph Lomb Medal, the Stuart Ballantine Medal of the Franklin Institute (1968) and Coblentz Memorial Prize (Pittsburgh Conference of Analytical Chemistry and Applied Spectroscopy) (1974). His work on mechanisms of gas laser excitation, quantum effects, nonlinear optical phenomena in the infrared and high resolution infrared spectroscopy has bearing not only on basic sciences but also has uses in many practical applications.

R. K. DATTA

Neutron - discoverer Dr. Chadwick passes away

DR. James Chadwick, winner of the 1935 Nobel Prize in Physics for his discovery of elementary particle neutron (1932), died on July 23, 1974 at the age of 82. He investigated at the University of Manchester under Lord Rutherford, the founder of nuclear physics, the existence of neutron as postulated by the latter. He demonstrated that electrically neutral particles were emitted when beryllium was bombarded with positively-charged alpha particles—these neutral particles were later found to be elementary particles of atoms and were named neutrons. His discovery of neutrons led to the development of nuclear energy and to the eventual development of atomic bomb. In early 1943 Dr. Chadwick joined Tube Alloys, the British atomic bomb project corresponding to the U.S. Manhattan District Project. Later that year he went to the U.S.A. as head of the British team to work in the Manhattan District Project that successfuly made the atomic bomb.

Born on October 20, 1891 in Manchester, young Chadwick graduated from the University of Manchester in 1911 and started research on radioactivity there under Lord Rutherford. Two years later, while he was in Berlin for research, he was interned in a concentration camp (during World War I). In the concentration camp he managed to set up a makeshift laboratory to carry on his research on a small scale. On his return in 1919 he joined Lord Rutherford who just then had moved to Cambridge University's Cavendish Laboratory. He got his Ph.D. degree from Cambridge University. Dr. Chadwick joined the University of Liverpool in 1935 as the Jones Professor of Physics. In 1948 he was made Head of Gonville and Caius College, Cambridge University. Recipient of Copley Medal (1950) and Franklin Medal (1951), Dr. Chadwick was knighted in 1945.

R. K. DATTA

Neutrino-discoverer physicist Dr. Cowan passes away

DR. Clyde L. Cowan, physicist and co-discoverer of the neutrino, died on May 24, 1974 in Washington. He was 54.

Dr. Cowan who was a pioneer in the monitoring of low levels of radioactivity and in medical uses of radioactive isotopes, discovered the neutrino in cooperation with Dr. F. Reines in 1956 while working in the nuclear weapon test division of the Los Alamos Scientific Laboratory in

New Mexico. Neutrino is an uncharged elementary particle less than one-tenth the size of an electron. The discovery of neutrino helped in the study of energy generation in the stars and in the knowledge of the structure of elementary particles.

Young Cowan was a graduate student of the University of Missouri and received his Ph.D. degree from the Washington University in St. Louis. During the World War II he served in the Chemical Corps and for Air Force radar development. He joined the Los Alamos Scientific Laboratory in 1949 and worked there until 1957 when he joined George Washington University. An year later, he moved to the Catholic University where he taught until death. Recipient of numerous awards, Dr. Cowan acted as a consultant to the U.S. Atomic Energy Commission and co-authored a textbook in physics.

R. K. DATTA

Committee for cooperation between CSIR and other scientific bodies

FOR greater cooperation between the Council of Scientific & Industrial Research, the Universities and the Institutes of technical education, namely, Indian Institutes of Technology, Regional Engineering Colleges, Indian Institute of Science, Bangalore, Birla Institute of Technology & Science, Pilani, Indian School of Mines, Dhanbad, etc., which have direct dealings with the Ministry of Education, it has been decided to constitute an inter-ministerial committee consisting of the following :

1. Director-General, CSIR & Secretary to the Government of India—Chairman
2. Vice-Chairman, University Grants Commission—Member
3. Additional Secretary, Ministry of Education & Social Welfare—Member
4. Director (U), Ministry of Education & Social Welfare—Member
5. Director, National Physical Laboratory, New Delhi—Member
6. Director, Indian Institute of Technology, New Delhi—Member
7. Deputy Educational Adviser (Tech.) incharge of IIT's in the Ministry of Education—Member Secretary

The objective of forming this Committee is to discuss problems of cooperation and coordination which crop up during the day-to-day working and in the process of the plan formulation and implementation.

Prime Minister's Message to Indian scientists

IN her letter to the scientists of the Bhabha Atomic Research Centre (BARC), the Prime Minister, Shrimati Indira Gandhi, in a reference to the 18 May epoch-making underground nuclear explosion designed for nation-building purposes, has stated that the peaceful underground nuclear explosion is symbolic of our nation's recognition that in the contemporary world, science and technology constitute a major resource in the nation-building process. "It is symbolic of our determination, as a consequence, not only to develop a capability in any area of advanced science and technology which we feel will help our progress, but to do so on the basis of self-reliance. It also demonstrates what Indian scientists and engineers of different disciplines and coming from different parts of the country can do through dedication and disciplined team work." The Prime Minister concluded her congratulatory message by saying: "I am proud of the Scientists of the BARC and of the larger national scientific community of which they are a part."

MEDICAL NOTES

Cancer vaccine efficacious in primates developed

WHILE herpes-viruses are said to cause human malignant tumour, no clinical trials in man with viral vaccines against tumour-producing herpesviruses have been successful. Last year, Dr. R. Lauf and his associates at the Hygiene Institute of the University of Gottingen, West Germany demonstrated that the tumour-producing herpesviruses derived from monkeys could be used *in vivo* to study the problems of herpesvirus cancer vaccines (*J. Natl. Cancer Inst.*, **51**, 599, 1973). Since herpesvirus saimiri (HVS) regularly induces malignant lymphoma in cotton topped marmoset monkeys (*S. oedipus*), Dr. Lauf developed a vaccine from killed HVS and tested for safety and efficacy in the primate model system (*Nature*, **249**, 571, 1974). The killed vaccine, when given in four or five intramuscular injections to each animal, induced in all monkeys high levels of antibodies against HVS. The vaccines were found to be neither infectious nor tumour-producing. All immunized monkeys remained clinically well up to at least 9 months. The vaccine delayed tumour development in monkeys that were given large doses of infectious HVS compared to control monkeys that were similarly infected with HVS. Dr. Lauf believed that his study could be expanded to check the possibility of developing a vaccine against Burkitt's lymphoma, which mostly inflicts African children and is said to be caused by a herpesvirus (Epstein-Barr virus).

BHAKTI DATTA

Triggering of protein synthesis in embryo

THE triggering of protein synthesis in the first stages of embryonic development is not fully known, though one mechanism involving the activation of ribosomes following fertilization has been proposed (R. Maggio *et. al.*, *J. Mol. Biol.*, **31**, 621, 1968). Ribosomes are granules that line up amino acids into specific proteins under the direction of messenger RNA. A refinement of this mechanism came when an inhibitor of protein synthesis was isolated from ribosomes of unfertilized eggs of *Paracentrotus lividus* by extraction of ribosomes with high concentrations of salt (S. Metafora *et al.*, *Proc. Natl. Acad. Scis. U.S.*, **68**, 600, 1971). This inibitor was a protein, not a ribonuclease, and decreased ribosomal binding of a synthetic messenger RNA and transfer RNA. Further, it was found that this inhibitor was absent from extracts of ribosomes of *P. lividus* blastula, suggesting that it disappeared abruptly when eggs were fertilized. Some further light has recently been shed on this protein synthesis inhibitor of the first stages of embryonic development when Dr. M.B. Hille of Seattle's University of Washington isolated a protein synthesis inhibitor from ribosomes of unfertilized eggs and embryos of sea urchins (*Strngylocentrotus purpuratus* (*Nature*, **249**, 556, 1974). He not only confirmed the occurrence of the inhibitor in unfertilized eggs, but also found it in the embryo. This inhibitor was a protein, not a ribonuclease nor a guanisine triphosphatase. While previous investigators suggested that the inhibitor disappeared after fertilization, the present investigator Dr. Hille found a gradual diminution in the amount of the inhibitor and suggested that slow loss, rather than abrupt disappearance, of the inhibitor was responsible for continuous protein synthesis observed until mesenchyme blastula or early gastrula (W.B. Berg, *Expt. Cell Res.*, **49**, 379, 1968).

BHAKTI DATTA

Reconstitution of mammalian cell with separate nucleus and cytoplasm

DRS. G. Veomett, D. M. Prescott, J. Shay and K.R. Porter of the Department of Molecular, Cellular and Developmental Biology of the University of Colorado at Boulder recently developed a procedure for the reconstitution of mouse cells from the separated cytoplasm and nuclei (*Proc. Natl. Acad. Scis. U.S.*, **71**, 1999, 1974). The nucleus contains the hereditary materials or genes

(Continued on page 410)

SCIENCE FOR THE YOUNG

Principles of colour photography

WE are all familiar with the seven colours of the rainbow. We like to capture these colours in our photographs and see the pictures of the different objects in their natural colours. The understanding of the principles of colour vision has made colour photography possible. The first successful theory of colour vision was proposed by Thomas Young and others and is known as the trichromatic theory of colour vision. According to this theory, the visual sensation of the different colours of the rainbow can be produced by a suitable combination of only three primary or independent colours—red, green and blue. This can be demonstrated by arranging three projectors as shown in Fig. 1. Each one of the projectors is provided with filters of one of the primary colours. The three primary colours coming out of them are projected on a white screen. We find that the different regions appear coloured as marked in the figure. When the three colours are of equal strength, we get white light. When the different primary colours are in different strengths, we get the different colours of the rainbow. In mathematical language the equation for colorimetry takes the form:

$$X = C_1P_1 + C_2P_2 + C_3P_3$$

where X is the colour to be matched, P_1, P_2 and P_3 are the primary colours and C_1, C_2 and C_3 are called the trichromatic coefficients which may be positive or negative.

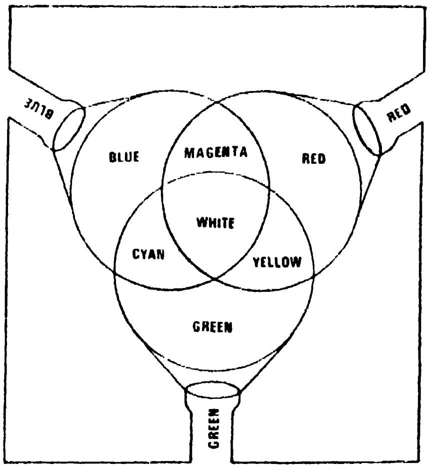


Fig. 1. Principle of colour synthesis

Colour films

In black-and-white photography we use chemicals on the film surface which are affected by the brightness or darkness of the object. In colour photography we have to look for chemicals which are affected differently by the various colours. Since all the colours can be produced by a suitable combination of the three primary colours, it will be enough if we look for chemicals which are affected by the three primary colours only. The chemicals will break up the colours of the subject into the three basic colours and record them on the film in the proper proportions. When these primary colours are added up we get the original colours of the subject. This process is called colour addition. There is another process in colour photography. This process is called colour subtraction. We have seen that the addition of equal strength of red, green and blue gives white. We can consider yellow as 'white minus blue', cyan as 'white minus red', and magenta as 'white minus green'. Thus we can write down the addition and subtraction formulae for the different colours as shown below :

Yellow $= G + R = W - B$
Cyan $= B + G = W - R$
Magenta $= B + R = W - G$

The yellow and blue are said to be complimentary colours. Similarly cyan is complimentary to red and magenta is complimentary to green. It may be noted that the subtractive primaries represent the colours complimentary to additive primaries. For example, $G + R$ is complimentary to B. The equation $W - B = G + R$ proves the above statement. In order that the film may respond to the three primary colours coming from the subject, a typical colour film is made of three different emulsion layers and one filter as shown in Fig. 2. The top emulsion layer is sensitive only to blue light, the second to green and blue and the third to red and blue. A yellow filter is interposed between the first and the second emulsion layers. This filter prevents the blue colour from going beyond the blue-sensitive first layer. Each colour in the original scene affects one or more layers of the colour film. Let us consider a typical example

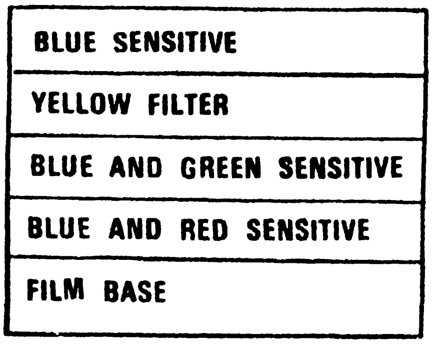


Fig. 2. Emulsions on a colour film

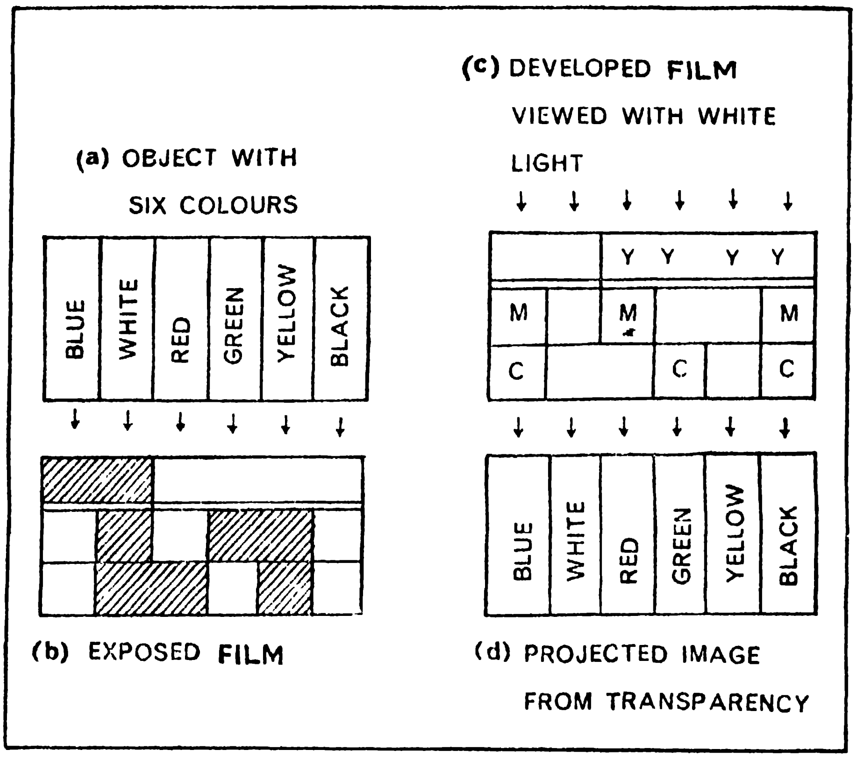

(a) OBJECT WITH SIX COLOURS
BLUE
WHITE
RED
GREEN
YELLOW
BLACK
(b) EXPOSED FILM
(c) DEVELOPED FILM VIEWED WITH WHITE LIGHT
Y
Y
Y
Y
M
M
M
C
C
C
BLUE
WHITE
RED
GREEN
YELLOW
BLACK
(d) PROJECTED IMAGE FROM TRANSPARENCY

Fig. 3. Processing of colour film (diagrammatic)

in which a subject has the six colours shown in Fig. 3a. Let us see the various steps involved in the exposure and development of the colour film.

In the figure, we see that while black does not affect any of the layers, white affects all the three layers. Blue affects only the first layer as it cannot reach the second and the third layers because of the yellow filter. Red affects the third layer only, green affects the second layer only and yellow affects both the second and the third layers. Developing is a reversal process. During this process the layers not affected by the particular colour are dyed by the corresponding complimentary colours and the affected portions become transparent as shown in Fig. 3c. This gives a colour transparency. When the colour transparency is viewed by white light or projected on a screen the natural colours of the original object are seen. The subtractive colours in the three layers produce the original colours as faithfully as possible under the existing conditions of emulsion sensitivity and dye colours.

R. Ramaswamy

MEDICAL NOTES *(Continued from page 408)*

that dictate the cell's functions, while the surrounding cytoplasm contains the complex chemical machinery that translates the genetic instructions. Basically, the procedure developed by these investigators permitted nuclei to be taken out of mammalian cells by centrifugation, and then transplanting the nuclei into different cells that had their nuclei removed. In this procedure, the investigators grew mouse cells in tissue cultures, labelled nuclei of some cells with radioactivity and the cytoplasm with minute latex spheres (1.0 μm diameter). In other cells, the investigators did not label nuclei with radioactivity but labelled the cytoplasm with latex spheres of a slightly smaller diameter. Next, they treated cells with cytochalsin B, a fungus material, that made the nuclei move towards the walls of the cells so that they could be easily separated by slow centrifugation. After the nuclei and cytoplasm were separated, they were exposed to inactive Sendai viruses, which caused them to fuse into new cell bodies. The labelling technique as stated above indicated that the separated nucleus from one cell fused with separated cytoplasm of another cell. The new cells were found to be capable of cell division and growth in tissue culture.

In their first experiment the investigators produced more than 200 such hybrids, each having a single nucleus housed in a foreign cytoplasm. They had since been able to increase the yield greatly. This succesful reconstitution of mammalian cells may reveal some of the secrets of aging, of cancer, and of some basic processes of life. Thus, for example, large number of aged cells could be given nuclei from young cells, or cancer cells could be given the genetic and chemical mechinery of normal cells.

R. K. Datta

SCIENCE IN INDUSTRY

Decolorizing synthetic tanning materials

MANUFACTURERS of synthetic tanning materials can now improve the quality of their product by adopting the latest technique for bleaching, developed by the Central Leather Research Institute (CLRI), Madras. The Syntans, heated for an hour with a mixture of chemicals (which are easily available), give the bleached product. This bleaching process improves the quality of the product and in turn the tanned leather, giving them light pastel shades. The bleaching is very quick but at the same time it does not change the characteristics and properties of the product on ageing. The process is not only useful for tanning materials of phenolic and naphthalene type but also could be effectively used in the bleaching of vegetable tanning extracts.

The process has been developed on a laboratory scale on 2 to 2.5 kg batches with reproducible results. The process does not need any capital investment, as this is only an intermediate step in the manufacture of Syntans and therefore would be of interest to manufacturers of Syntans. The introduction of bleaching operation during manufacture of Syntans would increase the cost of production of Syntans by Rs. 75 to 100 per tonne. But this would be compensated by enhancement of the quality and utility of the product.

Scope of refractory industry in Uttar Pradesh

REFRACTORIES are mineral-based products and are consumed by various industries in construction and maintenance of furnaces. There are already some industries like cement, sugar, chemical and engineering in UP which require refractories and many other industries are coming up. Till now there is practically no refractory manufacturing unit in UP and almost the whole of the requirement is being met from production centres situated in other states, particularly Bihar.

There is a definite shortfall in the availability of fireclay refractories and high alumina refractories in the 5th Five Year Plan. The shortfall is expected to rise gradually up to about 3,00,000 tonnes by 1979, as revealed by the report of the Refractories Committee of the Ministry of Steel & Mines, Govt. of India. The shortfall for silica bricks and dead burnt magnesite in 1979 will also be of the order of 10,000 and 49,000 tonnes respectively.

Central Glass and Ceramic Research Institute (Calcutta) has thoroughly studied almost all the refractory minerals present in the State and has found them very much suitable for the purpose. Fireclay from Bansi of Mirzapur District, diaspore and pyrophyllite from Jhansi and magnesite from Almora have been investigated by CGCRI for the production of various types of fireclay refractories, high alumina bricks and basic bricks. A large number of investigational reports regarding the suitability of the raw materials have been submitted both to the State Govt. depts. and to private parties. Besides these, bauxite of grade I quality is present in Banda district in UP. Many deposits of fireclay and quartzite which are suitable for making refractories have been reported in the adjoining States of Madhya Pradesh and Rajasthan. Even the best fireclay deposits of Bihar are well connected with Mirzapur in UP.

Based on the findings of the Central Glass & Ceramic Research Institute on Almora magnesite, a unit for producing dead burnt magnesite has been established under the joint auspices of the State Govt. and the Tata Group of Industries. Similarly, the results of the investigation on diaspore from Jhansi have put the material in commercial use for the last 7 to 8 years. Now there is ample scope for putting up a refractory manufacturing unit for making fireclay and high alumina refractories from the minerals available in UP, namely, diaspore, pyrophyllite and Bansi fireclay. Production of silica bricks is also possible by utilizing quartzite from the neighbouring states of Madhya Pradesh and Rajasthan.

Other infrastructural facilities like power, fuel, water supply, communication by road and railways etc. are also available for establishing refractory industry in Uttar Pradesh.

A small economically viable unit of 6,000 tonnes annual capacity may be established for special refractories with an investment of about Rs. 60 to Rs. 70 lakhs.

BOOK REVIEWS

ENVIRONMENTAL POLLUTION AND MENTAL HEALTH by John S. Williams, Jr., Edward Leyman, Stephen A. Karp, and Paul T. Wilson, *Information Resources Press*, Washington D.C., 1973, Pp. xi+136, $ 9.50.

THE deleterious effects of polluted environment on human health has long been known, and the literature dealing with the subject is immense. However, studies of the processes by which environmental degradation affects man have so far been oriented mainly towards his physical health and well-being; the effect of pollution on mental health has been particularly neglected. The few exploratory studies that had been undertaken from time to time were either not well-documented or had been conceived in isolation from each other, thus being of little informative value. The volume under review—a product of a study commissioned by the National Institute of Mental Health of the USA—brings together the existing literature on the subject in a manner that would provide both a general overall view of the impact of pollution on mental health and foster systematic research on the subject.

The authors, a four-man team comprising a teacher and researcher in sociology, a specialist in information analysis, a professor of psychology, and a teacher and practitioner in psychiatry, analyse the available data on the adverse effects of pollutants on human behaviour and attempt to demonstrate specific lines of inquiry that need to be developed.

The 110 citations and abstracts included in the book are grouped broadly into four categories according to the types of degradation of the physical environment. Most of the first 64 papers on pollutants relate primarily to organic brain syndromes and mental retardation.These studies also examine the distribution of the pollutants in the environment, their effects on the body at various concentrations, and the population groups that have particularly high risks of exposure.

The effect of noise on mental health constitutes the subject matter of the 24 papers that follow. They describe studies such as of relationships of duration and intensity of noise to subjective levels of annoyance, ability to think practically, and irritability.

The papers on substandard housing illustrate how bad housing plays an important role in the development of mental illness. One aspect of substandard housing which has received special attention is overcrowding. Some of the studies indicate a strong relationship of dwelling unit crowding to mental illness while a few others indicate that density itself is unrelated to morbidity. Such discrepancy in the findings probably arises from different ways of relating density to other variables. For example, the effects of crowding may differ among occupational and ethnic groups.

The last five papers deal with the relationship between environmental stimulation or recreational activities and mental health.

The many factual examples described in the book not only illustrate the fact that environmental pollution does disturb the subtle equilibrium which we call mental health, but also provide material for elucidating the mechanisms through which mental health is effected. The book will be a useful reference document that may encourage more systematic research on this little-explored field.

BIMAN BASU

BHAGIRATH (April 1974), Edited by Radha Kant Bharati, *Publication Division*, Ministry of Information & Broadcasting, Patiala House, New Delhi 110001, Pp. 36, Annual, Rs. 3.00, per copy Re. 1.00.

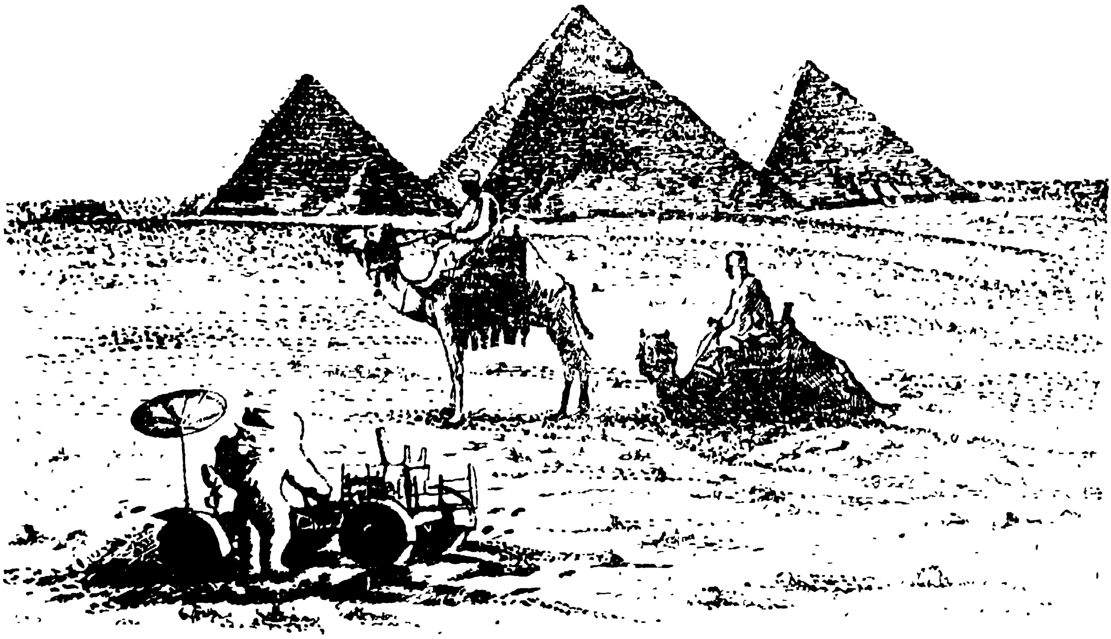
THIS is the first issue of the Hindi quarterly of the Central Water and Power Commission published by the Ministry of Information & Broadcasting. It aims at disseminating information to the Hindi-knowing people about the plans and programmes in the fields of irrigation and power undertaken by the government which are so vital for the development of agriculture and industry.

The opening article on rural electrification by Prof. Sidhweshwar Prasad, Deputy Minister for Irrigation and Power, deals exhaustively with the set up, working, and prospects of the five pilot rural power cooperatives in the states of Andhra Pradesh, Karnatak, Gujarat, Maharashtra and Uttar Pradesh. The article by the Chairman of the Central Water and Power Commission, Shri Y. K. Murti, depicts a vivid account of the water resources of India and their optimum utilization. Then there are other features on Gobar gas, thermal power stations, power development in Rajasthan, etc.

Since the magazine's maiden performance is satisfying in all respects of matter, printing and get-up, it may be expected that it would rise upto the goal for which it has come into existence.

C.B. SHARMA

Did Space Explorers Visit Ancient Egypt?



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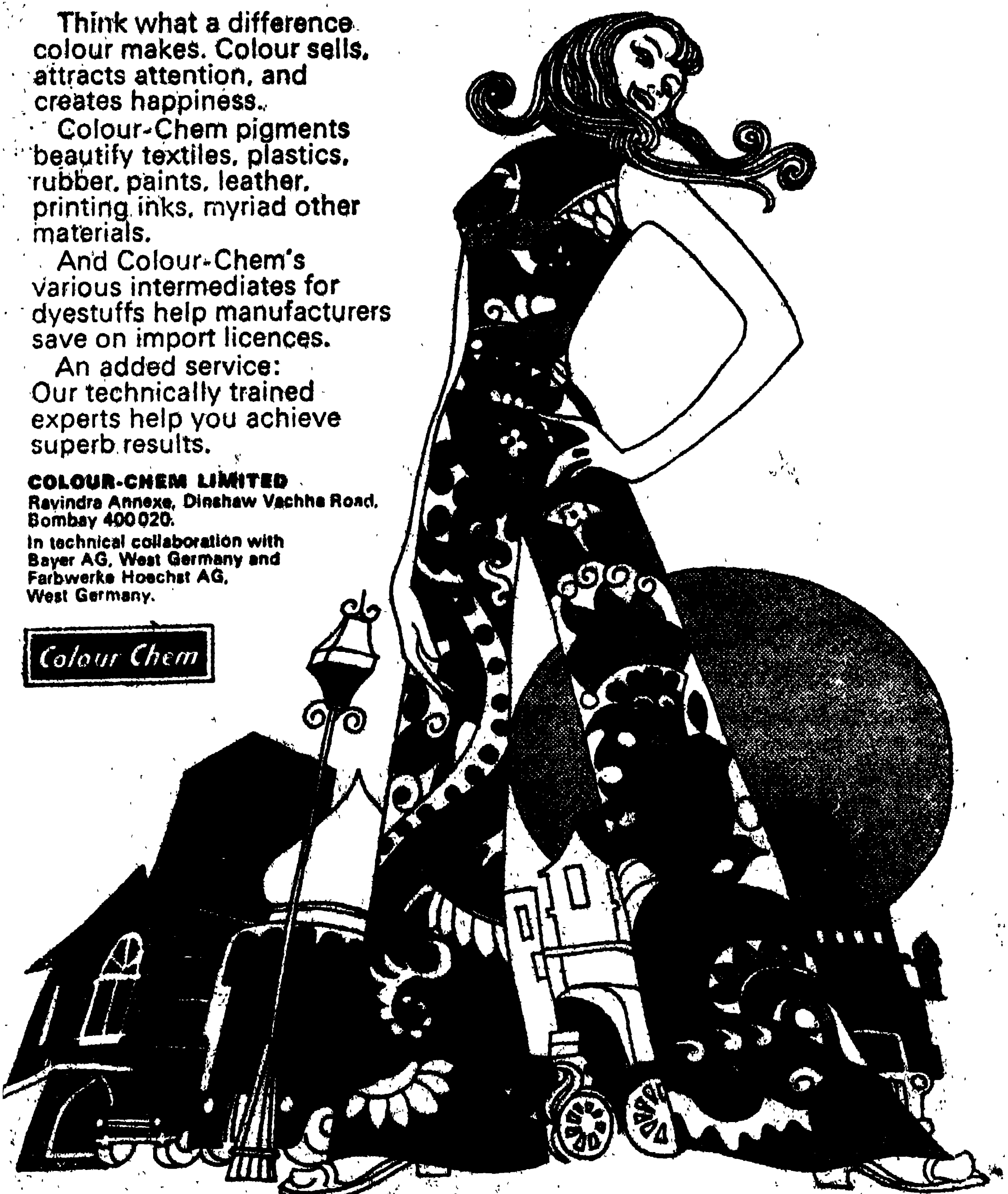

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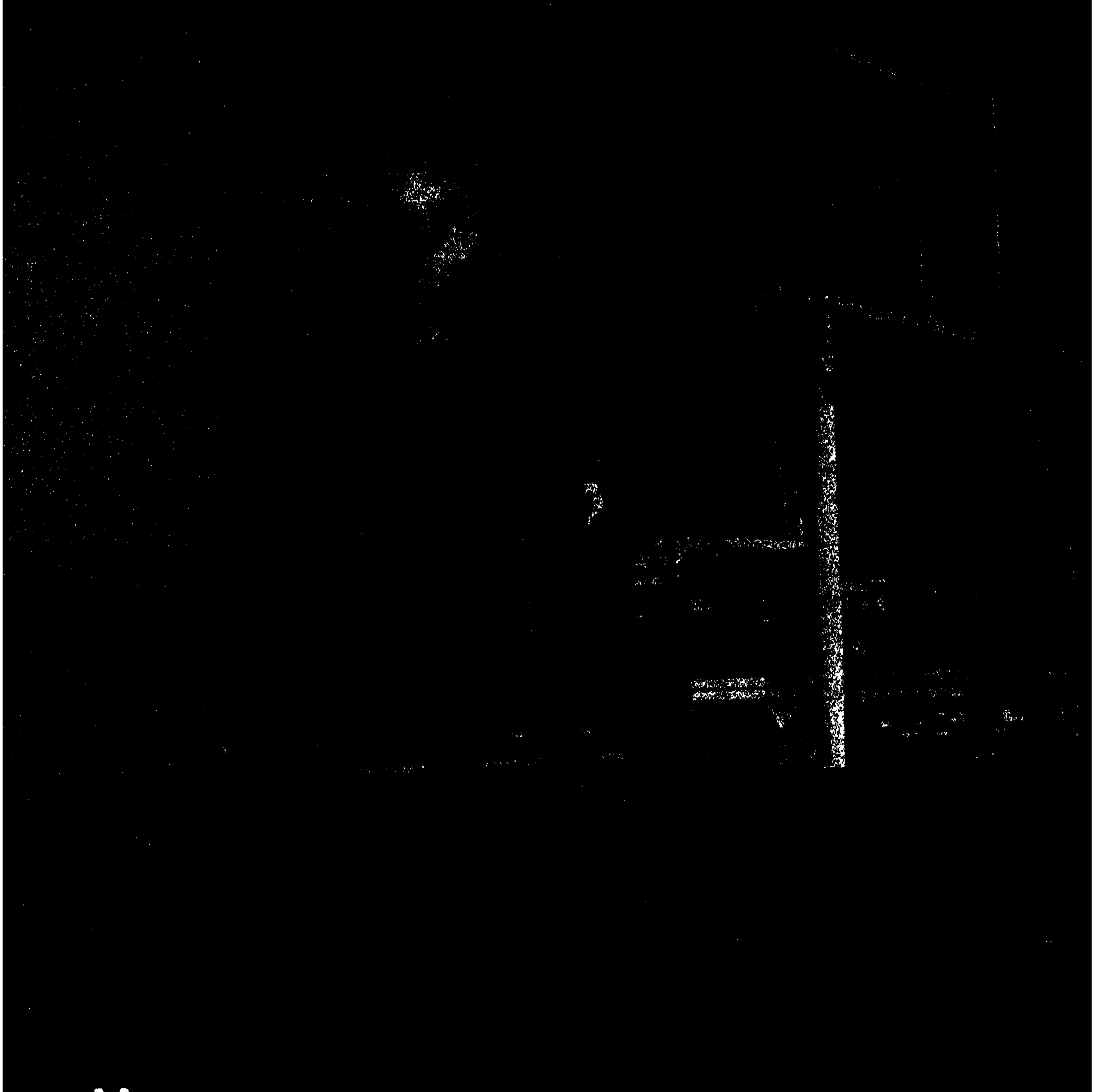

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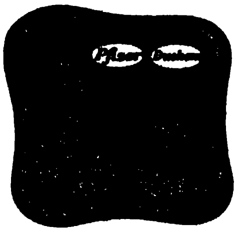

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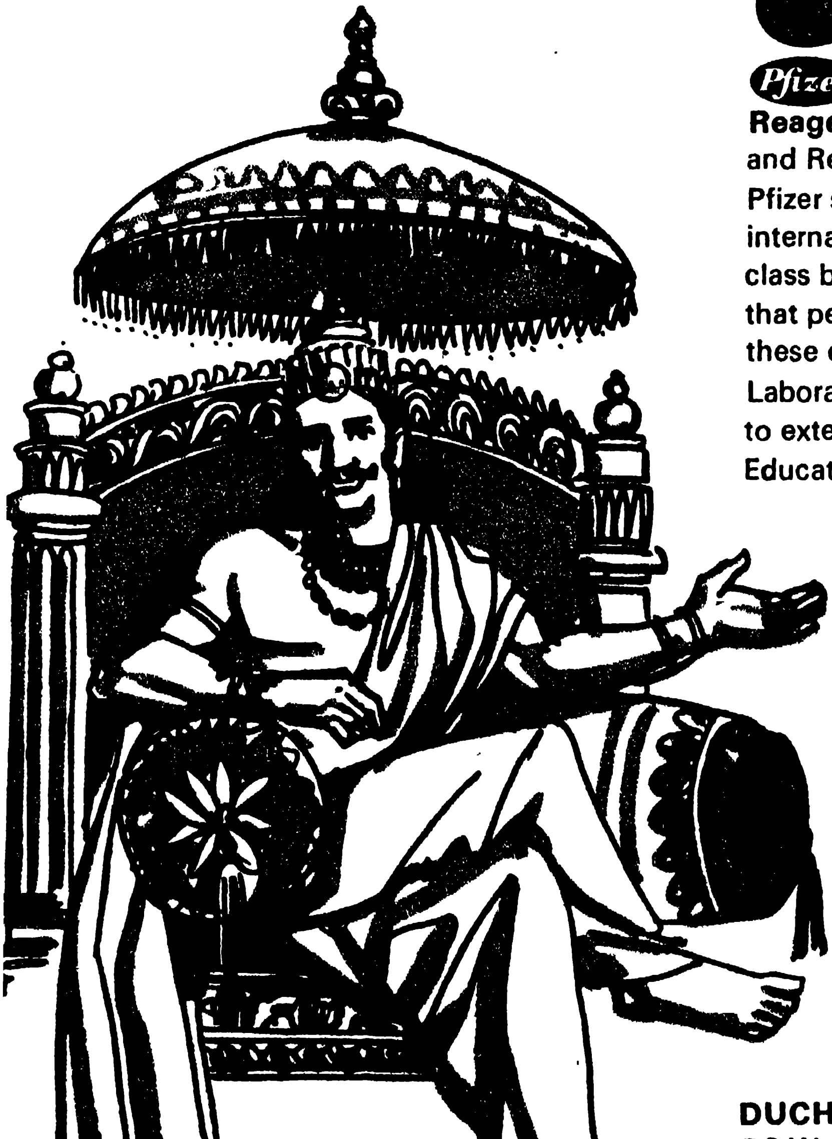

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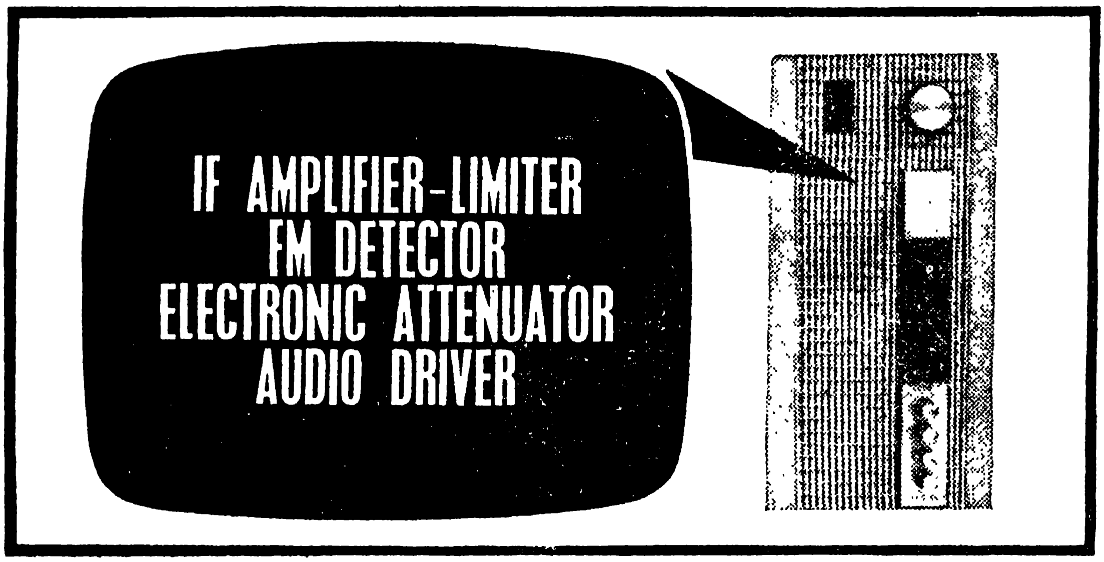

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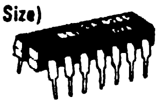

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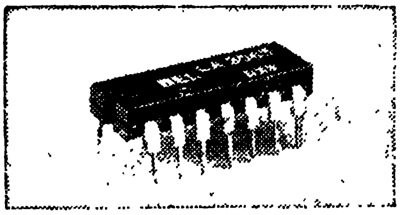

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LETTERS

Blood groups

Sir, Apropos "Blood groups and blood transfusion" (*S.R.* January, 1974). I would like to add the following.

M-N type of blood group was first discovered by Landsteiner and Levine. They injected different human blood samples into guinea pigs and found that these two antigens M and N, are responsible for the development of antibodies in the serum of the guinea pigs. As human beings do not produce any antibodies which react with these antigens, they have little significance in blood transfusion. On the basis of these antigens people may be divided into M, N or MN blood groups.

The above work led to the discovery of a number of other antigens present in human blood. For example, it was found that one Mrs. Kidd became sensitized to an antigen present in her husband's blood with the result that her child showed some degree of antigen-antibody hemolysis, without any apparent indication of Rh-incompatibility. The antigen is now called the "Kidd factor" after Mrs. Kidd. 77% of the people in the United States are found to be Kidd-positive and 23% Kidd-negative.

A different antigen was recorded in a Mrs. Kell's case and it has been called the "Kell factor" Similarly factors after the names of Mrs. Lewis, Mrs. Lutheran, Mrs. Duffy and Mrs. Cellano have been recorded.

Now about fifteen different blood group systems have been discovered, the latest being a sex-linked antigen known as 'Xg'. But their participation in any maternal complications is very rare compared to the Rh-factor. In most of the western countries scientists are making use of these types of blood groups in criminal investigation.

P. MURALINATH
Govt. Junior College
Nellore (A.P.)

The Sarabhai crater

It is good that the International Astronomical Union has decided to rename the lunar crater Bessel-A, in the Sea of Serenity, after Dr. V.A. Sarabhai (*S.R.* July, 1974). Also, it may be mentioned here that three formations on the far side of the moon have been named after Drs. H.J. Bhabha, J.C. Bose and M.N. Saha.

S.K. GURTU
Defence Science Laboratory
Metcalfe House, Delhi

Articles

Sir, I read with interest "Microwave spectroscopy" (*S.R.* May, 1974). Please publish articles on (i) Nuclear magnetic resonance spectroscopy, (ii) Infrared spectroscopy, (iii) Raman spectroscopy, (iv) Electron diffraction, and (v) X-ray diffraction theory and applications.

M.P. NYAMATHI
Health Camp
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Jai Singh

Sir, I have read with great interest "Raja Sawai Jai Singh and contemporary Indian astronomy" (*S.R.* 11, 7).

Jai Singh has always evoked admiration of Indian scientists for his pioneering research in astronomy. He is often quoted as an example of the spirit of scientific enquiry in India. Someone should throw light on how Jai Singh got interested in the subject.

HARI SHANKER UPADHYAY
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Patna

Nocturnal emissions

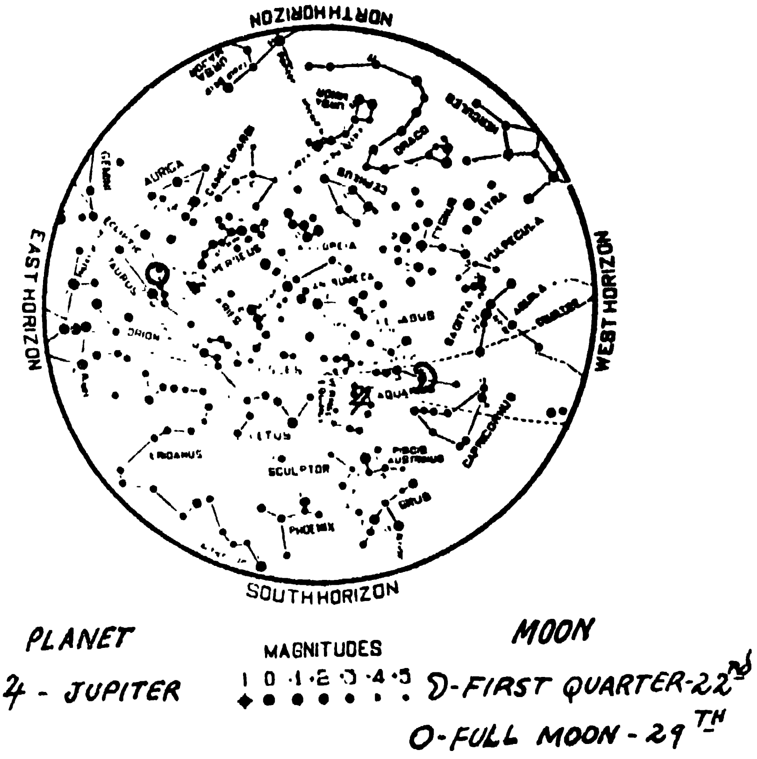
Sir, In recent years there has been much study of human sexuality. However, amid the vast new fund of factual data (Masters & Johnson, 1966), the relatively humble phenomenon of nocturnal emissions seems to have been almost entirely overlooked, although similar so-called "wet-dreams" have been shown to occur also in women. St. Thomas Aquinas (*circa* 1270) viewed the subject with typical objectivity: "Nocturnal emission is never a sin, but it is sometimes the result of a previous sin." Moral value judgements are outside the scope of this letter, however the implication that certain 'conscious activities' may sometimes result in a nocturnal emission should be noted.

Since there is an almost total lack of actual records on this subject it seemed worthwhile to obtain one. To this end, a record was kept by a healthy 22 year old student of all nocturnal emissions occurring over a celibate (both coition and masturbation-free) period of 157 days (actually nights), inclusive. For the present purpose a nocturnal emission is defined as the occasional and natural emission of semen occurring during sleep, which results in a return to a state of consciousness (waking). Hence an emission which did not result in waking would not be recorded. Neither would premature waking before orgasm was reached, even though erotic dreams may have occurred. It was important that the natural frequency should not have been disturbed during the record, because sexual activity tends to eliminate nocturnal emissions (although not erotic dreams), and sexual anticipation may have other exogenous effects. Certainly, it seems to promote beard growth (Anon., 1970). Perhaps this is why sufficiently long or reliable records are so difficult to obtain!

The nature of the record does not allow absolute conclusions being a one-subject study. However, some

(Continued on page 425)

PLANETS AND THEIR POSITIONS—NOVEMBER 1974



The moon

New moon occurs on 14th at 6–23 a.m. and Full moon on 29th at 8-40p.m. I.S.T. The moon passes about three degrees south of Saturn on 5th, about six degrees south of Mercury on 12th and seven degrees north of Jupiter on 23rd. The lunar crescent becomes first visible after the new moon day in the evening of 15th. The moon is at perigee or nearest to the earth on 8th and at apogee or farthest from it on 21st.

Lunar eclipse

There will be a total eclipse of the moon on 29th which will be visibl in India. The eclipse begins at 6–59 p.m. and ends at 10–28 p.m. IST.

The planets

Mercury (Budha) reappears as a morning star and rises about an hou before sunrise during the month. It becomes direct on 3rd and is at the greatest western elongation of about 19 degrees from the sun on 10th. It moves from Libra (*Tula*) to Scorpio (*Vrischika*). Its visual magnitude varies from +0.9 to -0.6.

Venus (Sukra) is too near the sun to be visible during the month. It is in superior conjunction on 6th. It moves from Libra (*Tula*) to Scorpio (*Vrischika*).

Mars (Mangala) is too near the sun to be visible during the first three quarters of the month. At the end of the month it reappears in the morning sky and rises about an hour before sunrise. It is in Libra (*Tula*).

Jupiter (Brihaspati) sets about an hour after local midnight during the first half of the month and at about local midnight during the second half. It becomes direct on 3rd. It is in Aquarius (*Kumbha*). Its visual magnitude is about -2.1.

Saturn (Sani) rises about four hours after sunset during the first half of the month and about three hours after it during the second half. It is in Gemini (*Mithuna*). Its visual magnitude is about +0.1.

(*Source:* Nautical Almanac Unit of the Meteorological Office, Alipore, Calcutta-27).

SUPERCONDUCTORS

I.M. TALWAR

If the coils of a magnet can be made superconducting, they would allow the construction of an extremely powerful magnet—much smaller in size and requiring low voltage. Such magnets find use as electrical and computer switching elements

SUPERCONDUCTIVITY is the name given to a remarkable combination of electric and magnetic properties which appear in certain metals when they are cooled to extremely low temperatures. Such low temperatures became available first in 1908, when Kamerlingh Onnes at the University of Leiden succeeded in liquefying helium, and by its use was able to obtain temperatures down to about 1K (degree Absolute).

One of the first investigations which Onnes carried out in the newly available low temperature range was a study of the variation of the electrical resistance of metals with temperature. It had been known for many years that the resistance of metals falls when cooled below room temperature, but it was not known what limiting value the resistance would approach if the temperature was reduced towards 0 K. Onnes experimenting with platinum found that when cooled its resistance fell to a low value depending on the purity of the specimen. At that time the purest available metal was mercury and in an attempt to discover the behaviour of a very pure metal, Onnes measured the resistance of pure mercury. He found that at very low temperatures the resistance became immeasurably small, which was not surprising. But more interesting was the manner in which the resistance disappeared completely. Instead of the resistance falling gradually as the temperature was reduced towards 0 K, the resistance fell sharply at about 4 K and below this temperature the mercury exhibited no resistance whatsoever (Fig. 1). Later on, it was discovered that this sudden transition to a state of no resistance was not confined to the pure metal but occurred even if the mercury was quite impure. Onnes recognised that below 4 K mercury passes into a new state with electrical properties quite unlike those previously known and this new state was called the 'superconducting state.'

Transition temperature

The temperature at which a superconductor loses resistance is called its superconducting transition temperature or critical temperature T_c. This is different for each metal. Not all the metals have been found to be superconductors. For example, copper, iron and sodium do not show superconductivity down to the lowest temperature to which they can be cooled. About half the metals and a large number of alloys are superconductors and the list is ever increasing. In general the transition temperature is not very sensitive to small amounts of impurity, but the superconductivity of a few metals such as iridium, molybdenum, which in the pure states have very low transition temperatures, may be destroyed by the presence of minute quantities of magnetic impurities. Such elements, therefore, only exhibit superconductivity if they are extremely pure; specimens of these metals of commerical purity are not superconductors.

Mathias has pointed out that there are certain conditions which apparently favour the appearance of superconductivity. For example to show superconductivity, a metal or an alloy must have an average of between 2 and 8 valence electrons per atom. In the case of transition metals and their alloys, an average of about 3, 4.7 or 6.4 valence elec-

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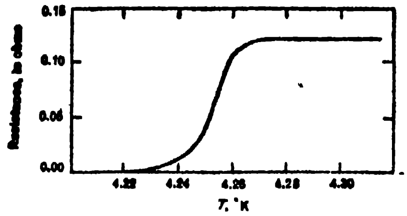


Fig. 1. Variation of resistance of mercury with temperature

trons per atom seems particularly favourable whereas 2.4 or 5.6 is unfavourable.

A large atomic volume seems to be unfavourable for superconductivity. Ferromagnetic substances are not superconductors. It is possible for an alloy to be a superconductor even if it is composed of two metals which are not themselves superconductors (e.g., Bi–Pd). On melting, the transition to superconducting state may be extremely sharp if the specimen is pure and physically perfect. For example, in a good gallium specimen the transition has been observed to occur in a temperature range of 10^{-5} degrees. If, however, the specimen is impure or has a distributed crystal structure, the transition may be considerably broadened (Fig. 2).

Critical field and current density

Superconductivity will disappear if the temperature of the specimen is raised above its transition temperature or if a sufficiently strong magnetic field or current density is made to flow through the superconductor. The applied field necessary to restore the normal resistivity is called the critical field, H_c. Furthermore, the superconductivity vanishes if the current flowing through the specimen exceeds a certain limit called critical current density I_c. Both H_c and I_c depend on temperature and on each other. Experimentally it is found that the critical magnetic field, at zero current, depends on temperature as follows:

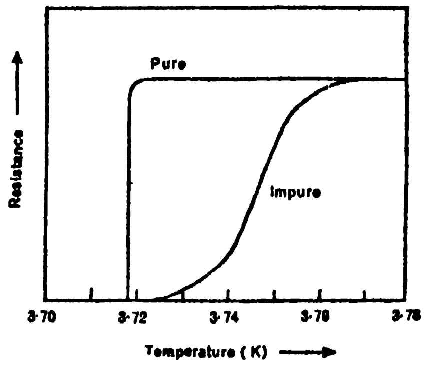


Fig 2. Superconductivity transition in tin]

$$H_c = H_{c_0} \; (1 - T^2/T_c^2)$$

where H_{c_0} is the magnetic field needed to destroy the superconductive state at $T=0$. For $T < T_c$, the material exists in two states; the superconductive state and the normal conductivity state. This is the basis for the operation of a cryotron.

Further, experimentally it is found that for a large number of superconductors H_{c_0} is related to the critical temperature by:

$$H_{c_0} = A\, T_c^{\alpha} \text{ where } \alpha = 1.8$$

Magnetic properties

The magnetic properties of superconductors are as remarkable as the electrical properties. The ideal magnetic behaviour of superconductors falls into two classes: Type I and Type II. Below the critical temperature and for $H < H_c$ the material is perfectly diamagnetic, i.e., the field does not penetrate the superconductor. This behaviour, illustrated in Fig. 3, is called Meissner Effect. It is also clear from the figure that when the specimen becomes superconducting, the field is concentrated at the sides of the specimen, but not at the top or bottom. When this happens, the specimen must exist as a mixture of normal and superconducting states called the intermediate state. If, however, the specimen were a cylinder instead of a sphere, and the applied field being parallel to the length of the cylinder, there is no intermediate state. Consequently such specimens are either superconducting (if $H < H_c$) or normal (if $H > H_c$).

Type II superconductors behave differently (Fig. 4). For applied fields below H_{c_1} (called the lower critical field), the material is diamagnetic, field is completely excluded. At H_{c_1}, the field begins to penetrate the specimen and the penetration increases until H_{c_2} (called the upper critical field). At this field the magnetization vanishes and the specimen becomes normal. The magnetization of a type II superconductor vanishes gradually as the field is increased, rather than suddenly as in type I superconductor.

Penetration depth and thin films

The applied field does not suddenly drop to zero at the surface of a type I superconductor, rather it decays exponentially. As a consequence, the field is fairly large over a distance from the surface. The penetration depth, λ, ranges from 300 to 5000 A° depending upon the material. Fig. 5 shows the penetration of the magnetic field into a bulk specimen and into a thin film whose thickness is less than the penetration depth. In ordinary specimens whose dimensions are much larger than 5000 A°, the major fraction of the volume is not penetrated by the field.

Hard and soft superconductors

Supercurrents will flow in a superconductor only where the magnetic field has penetrated. Ideal type I superconductors which carry currents only on the surface are, therefore, relatively poor current carriers. Although ideal type II superconductors can be thoroughly penetrated, they also carry a small supercurrent.

Non-ideal type II superconductors, on the other hand, carry large supercurrents, even at high magnetic fields. Their critical current density is, however, extremely sensitive to microstructure. Fig. 6 shows the effect of cold work crystallization, and precipitation heat treatment on a Nb 25 per cent Zr alloy. The higher the density of structural defects, the higher is the critical current. Addition

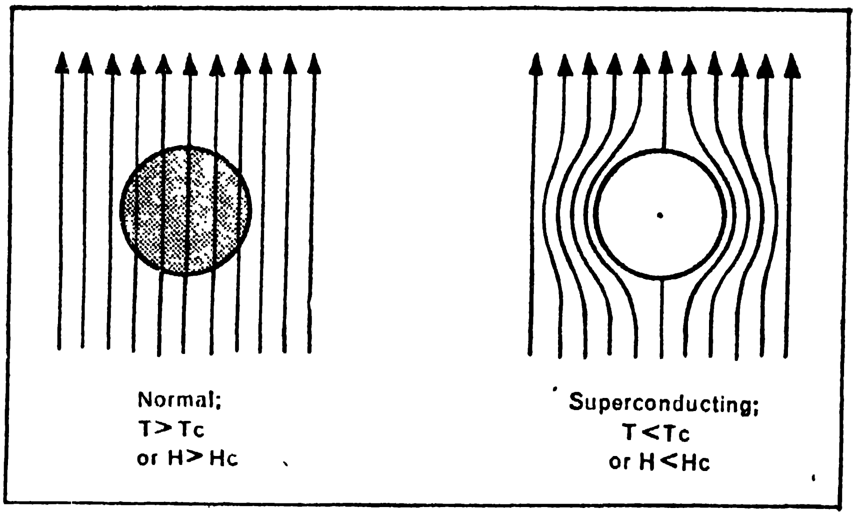


Fig. 3. Meissner Effect. (a) *Normal conductor*—the magnetic lines of force penetrating the specimen, (b) *Superconducting state*, the magtnetic lines of force expelled from within the specimen. They are concentrated along the sides in Type I superconductor

of interstitial impurities, especially oxygen, can induce fine-scale precipitation which raises the critical current.

Zero resistance

It can never be proved experimentally that the resistance in fact becomes zero, but the resistance of the specimen becomes less than the sensitivity of any perceivable apparatus, so that it has never been possible to detect resistance in the superconducting state. We may look for the resistance quite simply by passing a current through a superconducting wire and seeing if any voltage is recorded by a sensitive voltmeter connected across the ends of the wire. A more sensitive test, however, is to start a current flowing round a close superconducting ring and then see if there is any decay in the current after a long period of time. We cannot put an ammeter into the circuit to measure the current but the magnetic field produced due to circulating current can certainly be detected.

Causes of superconductivity

Although the development of quantum mechanics in the 1920's led to the understanding of the normal process of electrical conduction in metals, the origin of superconductivity remained obscure till 1956. This situation encouraged the development of phenomenological theories. These theories, although not an attempt to account for the origin of superconductivity, have established that most superconducting phenomena can be derived from a small number of empirical postulates.

An early attempt towards a phenomenological theory of superconductivity was made by Gorter and Casimir (1934) who showed that the thermodynamic properties of superconductors could be accounted for by assuming that their conduction electrons were divided into two 'fluids' or phases. The electrons in one phase are considered to retain their normal properties, but a part of them called 'superelectrons' are assumed to pass through the metal without resistance, i.e., suffer no collision. The fraction of superelectrons appears to decrease as the temperature is raised towards the transition temperature. At 0 K all

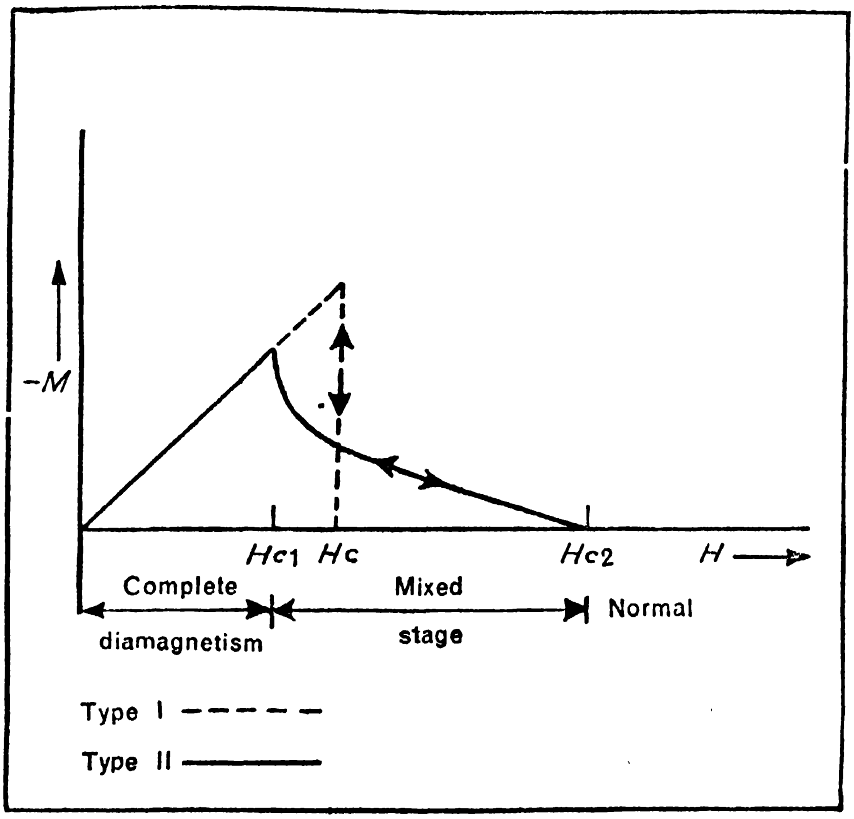
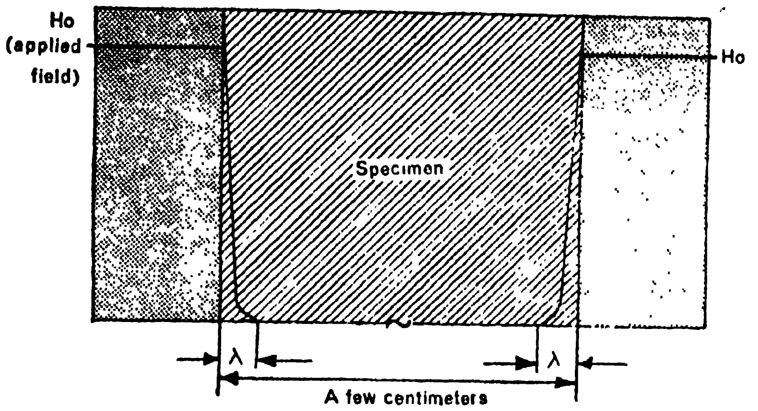
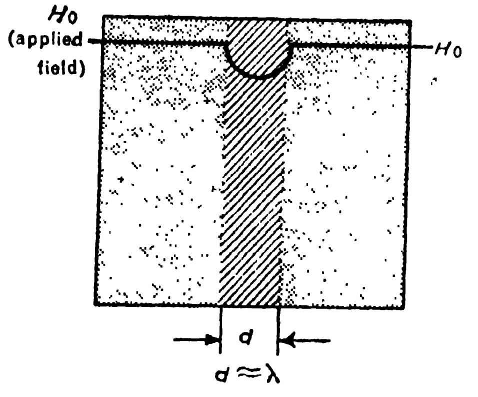


Fig. 4. Behaviour of type II superconductor under magnetic field



(a) A bulk specimen



(b) A thin film

Fig. 5. Penetration of the applied magnetic field into (a) bulk specimen, (b) thin film whose thickness is less than the penetration depth of the applied field

conduction electrons behave like superelectrons. But if the temperature is raised, a few begin to behave as normal electrons and on further heating the proportion of normal electrons increases. Eventually at the transition temperature all the electrons revert back to the normal state and the metal loses its superconductive properties. Hence a superconductor below its transition temperature appears to be permeated by two electron fluids: one of normal electrons and the other of superelectrons. The relative electron density in the two fluids depends on temperature. This is known as the 'Two-fluid model'.

Following discovery of the Meissner effect, it became clear that the electromagnetic properties of superconductors could not be predicted by considering Maxwell's equations of a metal and assuming zero resistivity. The brothers, F. and H. London (1935), were able to show, however, that most of the electromagnetic properties of superconductors including the Meissner effect could be accounted for by Maxwell's equations with the addition of another equation, called London equation. Though the subsequent work on superconuctivity has shown that the concepts of the two-fluid model and the London equation are exact only under certain limiting conditions, these concepts provide a convenient framework for explaining many phenomena related to superconductivity.

Following some earlier unsuccessful attempts by others to identify the low-temperature electron condensation mechanism believed to be associated with superconductivity, Frohlich in 1952 developed a theory that attempted to show that an electron could condense into a low energy state at low temperatures by distorting the adjacent portion of the lattice. Some years later, Cooper (1956) calculated that pairs of electrons could condense into a lower energy phase provided that there was some attraction, however weak, between them. Shortly afterwards, Bardeen, Cooper and Schrieffer (1957) were able to show that such an attraction does exist between electron pairs due to electron-phonon interaction. (A phonon is defined as a quantum of vibrational or acoustic energy, in analogy with the definition of a photon as a quantum of electromagnetic radiation energy). According to the theory of Bardeen-Cooper-Schrieffer, or BCS theory as it is generally called, the electrons responsible for superconductivity are coupled together in pairs, called Cooper pairs. These electrons have opposite spins and equal and opposite momenta. The attractive force between the electrons of a pair extends over a relatively long distance of the order of 10^{-4} cm., called the distance of correlation.

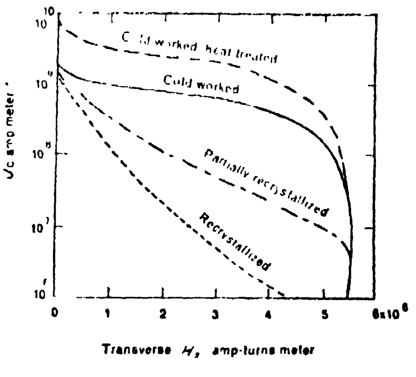


Fig. 6. Effect of different mechanisms of structural defects on the critical current density (material, Nb-/Zr)

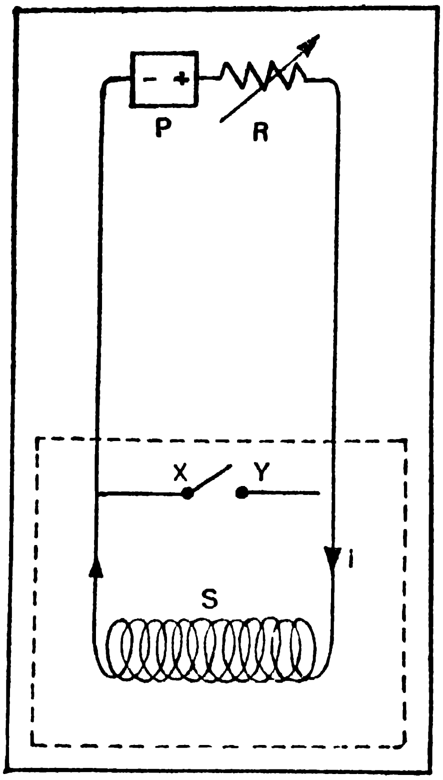


Fig. 7. Superconducting solenoid

The binding energy, 2△, between two electrons is temperature dependent and becomes zero if temperature approaches T_c. At absolute zero all electrons are paired, for $T_c > T > 0$ some electrons are paired and others are excited; for $T > T_c$ there are no electron pairs. The excited electrons behave normally in every respect; the paired electrons are responsible for superconductivity. Since there are electron pairs for $T < T_c$, the material is a superconductor for $T < T_c$.

Applications

Of the many possible applications of superconducting materials reported since 1911, generation of high magnetic fields by solenoids wound from superconducting wire is well established. One such solenoid is shown in Fig. 7. Current to the refrigerated superconducting solenoid *S* is derived from the d.c. power supply *P*. Once the current has been adjusted by the rheostat *R* to a value which gives the desired magnetic field strength, the superconducting switch *XY* can be closed. *XY* and *S* now form a closed, resistanceless circuit in which the flux remains constant. The field strength generated by *S* does not vary in time and the power supply can be disconnected when the field will be maintained by the current, *i*, flowing round the resistanceless circuit *XYS*. A superconducting solenoid operating in this fashion is said to be in the persistent mode. It is now-a-days possible to have solenoids wound with non-ideal type II Nb_3Sn and Nb-Zr wires developed by Kunzler and others (1961) at Bell Telephone Laboratories, U.S.A. to generate magnetic fields of the order of 30,000 K gauss.

To appreciate the utility of superconducting magnets, it is worthwhile to compare the cost of a conventional solenoid to that of a superconducting one. The cost of a conventional solenoid installation capable of producing a magnetic field 100 K gauss in a volume of 50 cc is more than ten times that of an equivalent solenoid wound with Nb_3Sn wire. Such a conventional solenoid furthermore requires 200 KW of power and 1000 gal/min of cooling water as well as considerable space for auxillary equipment. A superconducting solenoid, in contrast, occupies little space, has no steady-state power consumption, and uses relatively little liquid helium coolant.

Electrical switching elements

Because of the infinite ratio between the resistance of a metal in the normal and superconducting states, a superconductor can be used to switch electrical current between possible paths. Either temperature or magnetic field can be used to control the change of state of such a switch. In a temperature-controlled switch that uses a film of lead as switching element, the current carrying film is operated below the critical temperature so as to be superconducting. When it is desired to interrupt current flow through the switch, the lead film is raised above its critical temperature by means of a non-superconducting metal. As the lead film becomes resistive, current flowing through this is diverted through a parallel path of lower resistance.

A magnetically-operated current switch is shown in Fig. 8. It is operated slightly below the critical temperature (4.4 K) of the tantalum 'gate' wire. This acts as the current diverting element and can be switched to the normal resistive state by the magnetic field generated by passing current through the niobium 'control' wire. Niobium has a critical temperature above 80 K, so that the control remains superconductive during operation. The choice of tantalum for the gate wire allows the switch to be operated at 4.2 K i.e., in the liquid helium boiling at atmospheric pressure. Dudley A. Buck demonstrated (1956) that a device, which he named as 'cryotron', could be used as a digital switching element in computer circuit. The cryotron shown in Fig. 8 is also sometimes called 'wire wound cryotron' to distinguish it from 'metal-film' cryotron. A still modified form of cryotron called 'crossed film cryotron' was developed later in which both the gate and control are composed of metallic films separated by an insulating layer (Fig. 9).

For use as computer switching elements, film cryotrons appear to possess several advantages over the

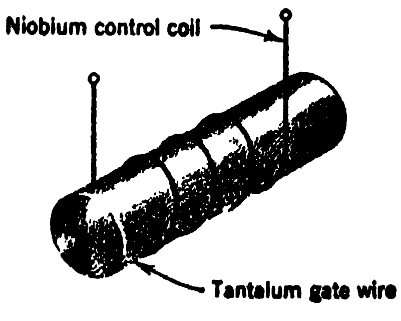


Fig. 8. A wire-wound cryotron

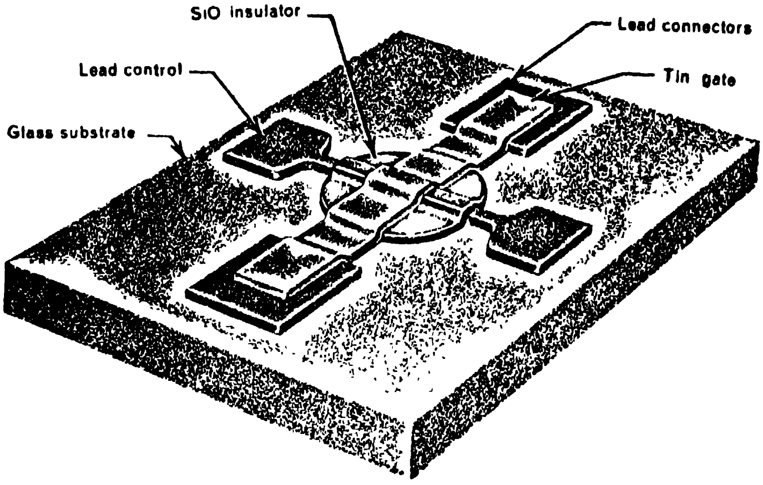


Fig. 9. A crossed-film cryotron

transistors presently being used. Film cryotron, in addition to being much cheaper, has the advantage of much low heat dissipation (of the order of few microwatts)—three orders of magnitude smaller than that of other high-speed amplifiers.

Further reading

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LETTERS *(Continued from page 418)*

interesting trends are evident. There appeared to be a three-day cycle of activity (Natural Frequency). This is not too surprising in view of the large number of endogenous circadian and other biological rhythms so far documented (Conroy and Mills, 1971). If emission occurs, it is highly unlikely that another will occur on the following night. There appears to be a greater probability of an emission occurring on a Friday night than on any other night (Imposed Frequency). Emissions on a Thursday (or Saturday) are less likely than on any other nights. In view of the cycle of penile erections which have been shown to be synchronous with REM dream states in the male (Fisher, *et al.*, 1964), and the evidence that certain types of dreams seem to have an inhibitory effect on such accompanying erections—it is not entirely unlikely that the mechanism of action of the imposed (exogenous) frequency may act through anticipatory inhibition of the Thursday night's possible emission. This is at least one necessary prerequisite, although the general week-end relaxation (or change of outlook, etc.) may prompt the actual emission on a Friday night.

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CURE BY CORTISONES

SRIDHAR RAO

Cortisones are rarely considered as drugs of the first choice. They are used when all other drugs have failed

CORTISONE is the hormone secreted by the adrenal glands situated above the kidneys. It was first used as a drug for the treatment of rheumatoid arthritis in 1947. The results were so dramatic that it was hailed as a miracle drug. Since then cortisones (a family of natural and synthetic hydrocortisone-like substances) have been used in the treatment of various diseases including some hitherto untreatable and obscure ones. In none of these conditions, however, they bring about cure; they only allay symptoms. Yet their potentiality appears so great that in the past decade or two they have received much more attention at the hands of scientists and research workers than any other group of drugs.

Hydrocortisone is one of the principal members of the family of cortisones. Cortisone (note the singular) differs from hydrocortisone in that it has an oxygen atom in place of one of the latter's two hydroxyl groups (Fig. 1).

Cortisone is believed to be an inert substance; its actions in the body are on account of its conversion in to hydrocortisone. Cortisone and hydrocortisone have now been replaced by synthetic cortisones in the treatment of all conditions except Adrenal Insufficiency Diseases (AI D) for which they are still the drugs of choice.

Prednisolone and prednisone are like hydrocortisone and cortisone respectively, but whereas the latter has only one double bond between the carbon atoms in ring A, the former has an additional double bond. Prednisone like cortisone is thought to be inert, its actions in the body is the result of its conversion into prednisolone.

Some newer members of the cortisone family are betamethasone, dexamethasone and triamcinolone. All these are more potent than cortisone. 25 mg of cortisone is equivalent in its pharmacolocal action to 20 mg of hydrocortisone, 5 mg each of prednisone and prednisolone, 4 mg of triamcinolone, and 0.75 mg each of betamethasone and dexamethasone.

Given orally, the cortisones are readily absorbed. Their action lasts for 8-12 hours. To obtain uninterrupted action they should be administered 2-3 times a day. Some cortisones can be given by intramuscular and intra-venous injections. Long term depot injections are available, as also, preparations to be injected into the diseased joints.

Cortisone medication should be terminated gradually and not suddenly. Its dose should be reduced in steps over a number of days. This is because cortisones depress the adrenals and cause a decrease in the indigenous production of hydrocortisone. The recovery of adrenals after cessation of therapy takes some days, hence supplementation with exogenous cortisones should be done. If this precaution is not taken, that is, if cortisones are withdrawn suddenly, the patient is liable to suffer acute shock.

In supplementing hormonal deficiency

The most logical use of cortisones is in conditions where there is a decrease in the production of hydrocortisone by the adrenals, such conditions are known as Adrenal Insufficiency Diseases. They are characterized by a bronze-like pig-

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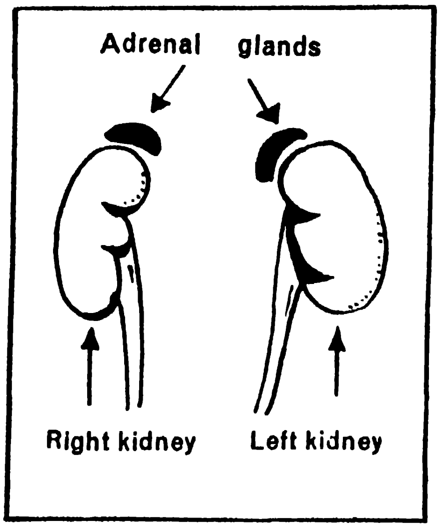

Fig. 1

mentation of skin, prostration, anaemia, low blood-pressure and digestive disturbances.

AID may arise primarily on account of pathological affliction (such as tuberculosis, fungal infection, tumour, etc.) or surgical removal of adrenals, or secondarily on account of a disease of the pituitary—a minute ductless gland at the base of skull which controls the secretion of hydrocortisone by adrenals. In primary AID, cortisone alongwith another hormone aldosterone, secreted by adrenals, is given. On the other hand, in secondary AID cortisone plus thyroxine with or without sex hormones is given, because pituitary commands not only the adrenals but also other ductless glands including those that produce thyroxine and sex hormones. The use of cortisones in AID is analogous to the treatment of insulin-deficiency diabetes with insulin. Therefore, their use should be continued as long as the patient lives.

Stress excites adrenals to produce more hydrocortisone. Such a hormonal excess is necessary for conditioning the body cells—the exact mechanism of which is unknown—to cope with the stress. It is for this reason that if a patient of AID on cortisone therapy suffers from shock, trauma, bleeding, infection or other kinds of stress, his need for cortisones increases. The dose should be doubled or trebled. Similarly, if he is required to undergo an operation, heavy doses of cortisones should precede and follow the surgical procedure.

As anti-inflammatory agents

Cortisones are used in the treatment of certain inflammatory conditions. Inflammation is the process by which the body attempts to destroy or at least contains the noxious agents that have attacked the body. These invading agents could be live microorganisms (in which case their attack is described as infection) or inanimate substances or even physical forces. The body deals with the noxious agents' protein component, if any, by a parallel mechanism of defence called the antigen-antibody reaction.

The earliest change in inflammation is the appearance at the site of attack of plasma cells, macrophages, giant cells, etc. These cells may be collectively called cells-of-defence (C.O.D.). Their action is to fight with and devour the noxious agents. Some of them arise locally. Many others are produced elsewhere and shipped to the battle ground by way of blood vessels.

The effective way in which a drug can benefit the body is by directly attacking or countering the noxious agents of inflammation. Instead of doing this, however, cortisones meddle with the body's attempts to deal with the noxious agents. They reduce the number of C.O.D. and decrease their capacity to devour the noxious agents. They prevent blood vessels from swelling up and becoming porous thereby decreasing the escape of C.O.D. and plasma. Due to less plasma exudation the formation of fibrous network is poor. The net result is that cortisones render the body an easy prey to the noxious agents, particularly to infectious organisms, suppress the inflammatory reaction and delay the healing process. On the credit side, they prevent scarring and adhesions.

Patients of AID who are on long-term cortisone replacement therapy are, however, not unduly prone to contract infectious diseases. In those cases cortisones are merely compensating for the under-secretion of hydrocortisone by the diseased adrenals. On the other hand, patients receiving long-term cortisones in pharmacological doses (over and above the hydrocortisone secreted by their adrenals) are prone to catch infectious diseases. These diseases are likely to produce greater destruction, and spread more readily in their body than in normal individuals. Similarly a healed and arrested focus of infection, as for example, that of tuberculosis, may become reactivated by cortisones and may then spread widely in the body.

There is one situation, however, that calls for the use of cortisones in the treatment of infections. This is when a man is suddenly attacked by a massive force of infectious organisms and has no time to mobilize his defences. The infectious organisms then colonize his whole body with lightning rapidity and pose a serious threat to his survival. In such an event, administration of cortisones prove life-saving by affording protection to body cells and making them less sensitive to the action of the infectious organisms. High doses of cortisones alongwith suitable chemotherapeutic agents are thus used in the treatment of acute fulminating cases of typhoid, tuberculosis, typhus, meningitis, infective hepatitis, etc. It should be remembered that as soon as the crisis is over, cortisones should be withdrawn, else they will interfere with the body's attempts to deal with the now-weakened invaders.

Many of the signs and symptoms of infections, such as redness, pain and swelling at the site of infection, fever, prostration, loss of appetite,

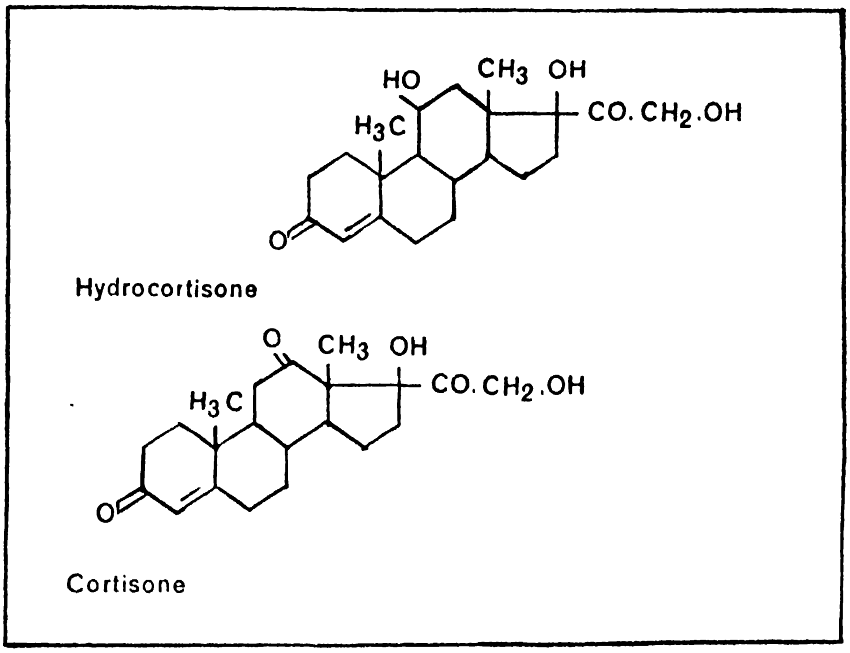

Fig. 2

etc., are the result of the accompanying inflammatory process. Since cortisones suppress inflammation they reduce such signs and symptoms. Alleviation of symptoms, on the face of it, appears beneficial but, with a few exceptions, it is harmful because the affected individual in the absence of the alarm signals does not seek medical aid, so that the underlying infectious process continues to progress unabated.

Masking of symptoms is useful occasionally in improving the outlook of a hopeless patient and making him physically fit and mentally prepared to undergo an operation that might provide him relief and perhaps even a new lease of life. Cortisones are sometimes used for this purpose in a grave disease called ulcerative colitis. It is a chronic condition with remissions and relapses, characterized by loose blood, mucous-containing stools, loss of appetite, anaemia and wasting. A very ill patient under cortisone therapy feels well. He regains normal appetite and begins to eat well. Soon his general condition improves to the extent that he is able to stand an operation in which his diseased colon is resected.

Similarly patients of such grave disorders of blood as thrombocytopenic purpura and haemolytic anaemia, who do not improve with conservative lines of treatment, may be put on cortisones for two to three weeks. If there is improvement, well and good. Else, they could be subjected to operation to remove their spleen.

Anti-allergy therapy

Any foreign substance acts as antigen on finding access to the body. The antigen may be alive such as the infectious microorganisms, or it may be non-living such as dust, pollen, dander, milk, egg, resin, etc. Excited by the antigen, the body produces in the course of 15-20 days substances called antibodies that are capable of neutralizing the antigen. The antibodies are produced by special cells (lymphocytes, plasma cells, reticular cells, etc.) found in spleen, lymph nodes, thymus and lymph patches in the intestines. There can be as many different antibodies as there are antigens. The antibodies produced by a particular antigen antagonize that antigen alone and have no action against any other antigen.

Cortisones decrease the number of cells that produce antibodies. They also exert a direct degrading effect on the antibodies. Thus, they suppress the antigen-antibody reaction. Because of this, they are of value in allergic and auto-immune diseases, but are used only after other drugs have failed.

Limitations

The usefulness of cortisones is severely limited by the numerous complications that arise when they are used in pharmacological doses for any length of time. Some of these could be dangerous and disabling and even life-threatening. Before prescribing them to any patient, the physician should be sure that the side-effects of cortisones do not add to the already existing illness. It should be noted that some members of the cortisones are likely to produce certain complications more frequently than others. Retention of water under the skin gives rise to the condition called oedema. The patient should be periodically checked for this condition. Rise in blood sugar may be noted. Cortisones are therefore forbidden in diabetes. There may be increase of pressure in the skull cavity leading to fits. The blood pressure may show a rise. Cortisones should not be used in patients suffering from heart diseases. Deleterious effects of cortisones on the stomach include hyperacidity, dyspepsia, peptic ulceration and reactivation of an healed ulcer.

Conclusion

The enthusiasm with which cortisones were ushered into clinical practice 24 years ago has passed and has left behind disillusionment. They

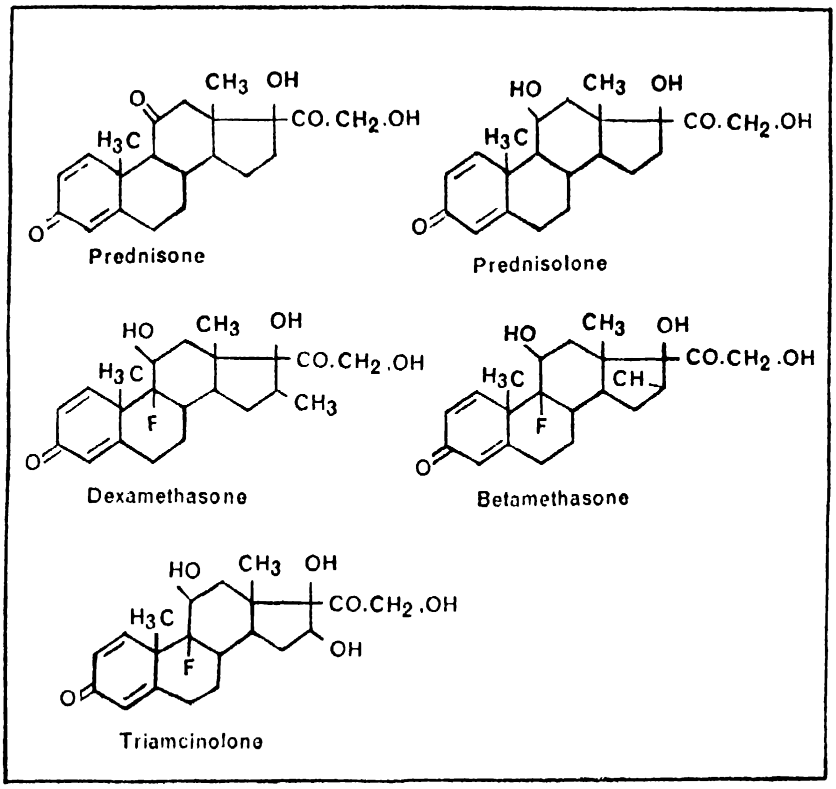

Fig. 3

are rarely considered as drugs of the first choice but only as a last resort when all other drugs have failed. Strictly speaking, they are not drugs because they merely mask symptoms; they do not pull out the root of these symptoms. So many complications are produced by them and the physician has to keep the patient under constant observation.

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WATER IN ATMOSPHERE

(*Continued from page 432*)

fibers by mutual repulsion. On the other hand, low humidity conditions are essential in certain drugs and chemical industry. Relative humidities down to 5 per cent are required for packing hygroscopic products. For storage and preservation of foodstuff like potatoes, oranges, etc., a right temperature and a right relative humidity are necessary. If humidity is too low the oranges, for example, would dry up while if it is too high, potatoes may rot.

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WATER IN ATMOSPHERE

S. K. KULSHRESHTHA

For comfort 30 to 70 per cent relative humidity is desirable

HYGROMETRY or psychrometry is an interesting science dealing with behaviour of water vapour present in the atmosphere. Humidity is a prime factor in air conditioning, both from the point of view of manufacturing requirements and human comfort. Air conditioning means maintaining suitable indoor temperature, relative humidity, and air motion at a desirable level and elimination of air-borne dust and dirt. On a larger scale, the effect of water vapour present in atmosphere on the daily weather and even local climate is considerable. Before going into details of moisture control, it is necessary to give a brief account of atmospheric air, sources of water vapour in atmosphere and the climate.

Atmospheric air

Atmospheric air, generally called 'air' in psychrometry, is a mixture of what is called 'dry air' and water vapour. Dry air contains by percentage volumes: nitrogen 78.03; oxygen 20.99; argon 0.94; carbon dioxide 0.03; and traces of rare gases. As a result of evaporation, the atmosphere absorbs large quantities of water vapour from oceans which occupy more than 60 per cent of our planet's surface. Water evaporates from equatorial oceans due to solar heat at the rate of nearly two metres per annum. In higher latitudes, water evaporates from any wet or moist surface at lower annual rates. The presence of water vapour in atmosphere can be viewed as dew and frost on the earth's surface and as clouds in free air. Fogs are low-lying clouds formed by air cooling below the dew point of its water vapour content, mostly prevalent when the sky is clear and when there is little or no wind. The largest amount of water is present in warm and moist regions and the lowest in cold and dry regions. Over the tropics, water vapour in atmosphere exceeds 30 gm per cubic metre of air, whereas saturated air at 0°C contains only 5 gm per cubic metre.

In lower regions of atmosphere, air movement is generally from the tropics to the poles. The moisture content is gradually reduced from the tropics to the poles as the air is cooled during its travel in the colder regions. Whenever water vapour in air is cooled below its dew point, condensation and precipitation occur. In some regions where there are mountains, the moisture-laden air is made to ascend so that expansion and subsequent cooling results. Air temperature falls about 9 °C per 1000 metre elevation due to expansion. Precipitation (rain or snow) can occur provided the air has a high relative humidity before rising. For this reason there is more moisture per cubic metre of air at ground level than at higher elevation; the moisture present in clouds per unit volume of air being much smaller.

Dry and wet bulb temperatures

The various terms used in hygrometry for temperature are: dry bulb temperature (dbt), wet bulb temperature (wbt), and dew point temperature. Dry bulb temperature is the temperature shown by the ordinary room thermometer. Wet bulb temperature is the lowest temperature indicated by a thermometer whose bulb is covered with a silk wick, wetted with distilled water and moved in air with a speed of 300 metre per minute. Water evaporates from the wick thereby cooling the latter. The temperature shown by the wet bulb thermometer is

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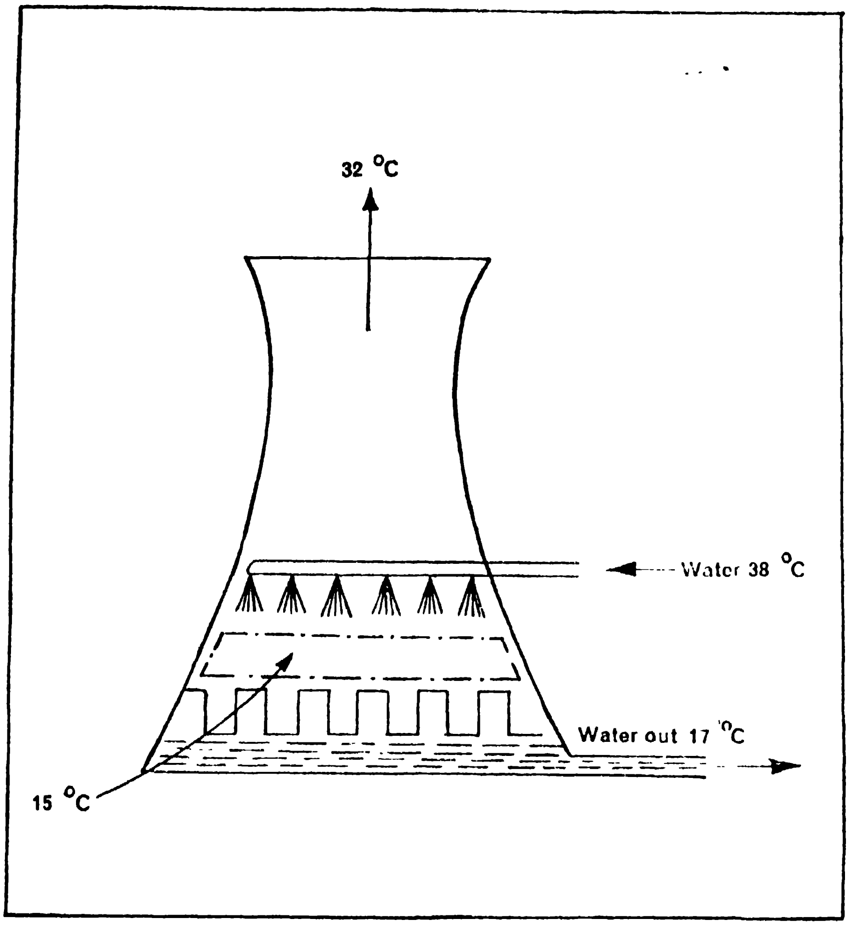

Fig. 1

thus lower than the dry bulb temperature. Under saturated air conditions (i.e., when the humidity is maximum) there is no evaporation of moisture from the wick, and consequently no cooling occurs; wet bulb temperature remains the same as dry bulb temperature.

Cooling towers used for cooling hot water from air conditioning and other industrial plants also work on the principle of evaporative cooling. In such towers, hot processed water is sprayed from a convenient height whereby some of the water comes into contact with the surrounding air and evaporates thereby cooling the water. Air movement is sometimes carried out by means of forced draught fans and induced draught fans. A cooling tower employing natural draught (without using mechanical appliances, fans, etc.) is shown in Fig. 1. Another illustrative example of evaporative cooling is the spray pond for cooling processed water of power houses and some industrial concerns. Here water is sprayed from below like a fountain. In air coolers (also called desert coolers) cooling is produced by forcing drafts of air from fans through wet fibre mats. They cool efficiently in hot and dry climates but are ineffective in humid climate or during rains.

Dew point temperature

Another important term used in air conditioning is dew point temperature. When atmospheric air saturated with water vapour is cooled, vapour pressure decreases and so does its capacity to absorb moisture. As a result excess moisture condenses into water droplets. The temperature below which the water vapour in air starts condensing is known as dew point temperature. In cold weather, when the outside temperature goes below dew point temperature, condensation is visible on the inside of window glass panes. The phenomenon is also seen during rains when the closed glass shutters of a car get fogged as the outside air gets cold. For the same reason, in humid weather water condenses on the outside of glass tumblers containing ice-cold drinks.

The principle is applied in summer air conditioning for dehumidification of air. Chilled coils or surfaces are used to cool the air below its dew point, the moisture gets condensed in droplets which are run off. The temperature of the chilled coil is controlled depending on the amount of humidity required.

Humidity

The commonly used terms of humidity in psychrometry are: specific humidity and relative humidity. Specific humidity is the ratio of mass of water vapour to the mass of dry air at a particular temperature of the air. Relative humidity is the ratio of actual water vapour pressure to the saturated water vapour pressure at the temperature of the air. Normally the vapour pressure or partial pressure of water vapour in air is a minute fraction of the atmospheric pressure. For example, saturated vapour pressure at 25 °C is 23.76 mm of mercury whereas atmospheric pressure has a value of 735 mm. Now-a-days, the unit millibar (mb) is used to express vapour pressure. 1000 mb being equivalent to the pressure of a column of mercury 750.13 mm high. Also 'absolute humidity' is the mass of water vapour in grams contained in a cubic metre of vapour-

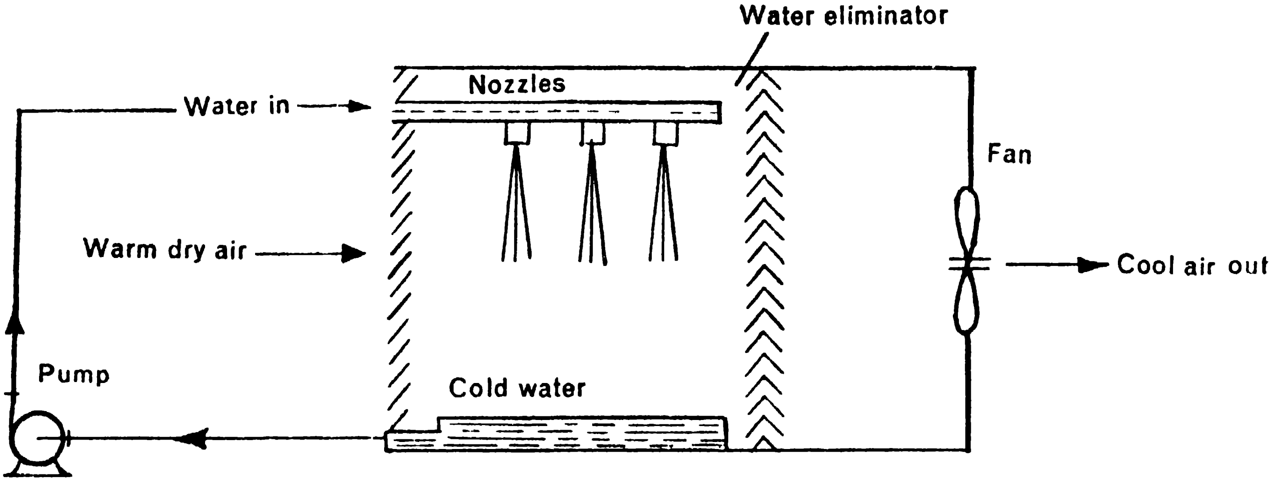

Fig. 2

air mixture at its total pressure.

Humidity plays a critical role in our feeling of comfort. For example, a room at 24 °C dbt and 25 per cent relative humidity appears cooler than one at the same dbt with 40 per cent relative humidity. The reason is that the human body is constantly giving off moisture which evaporates at a rate governed by the dryness of air; the drier the air more rapid is the evaporation. Thus one feels colder in dry air when evaporation is rapid than under conditions of higher relative humidity when evaporation is slow. For the same reason, on dry sunny days having low relative humidity, one may feel comfortable at a temperature about 26 °C, while on a day actually cooler according to dry bulb temperature but with higher relative humidity, he feels heavy and uncomfortable. Under such conditions discomfort can be lessened by increasing the air circulation. For comfort 30 to 70 per cent relative humidity is mostly desirable. Below 30 per cent relative humidity, as is sometimes noticed in desert areas, evaporation from the skin surface is so rapid that mucous membranes and the skin surface tend to dry out. Under such conditions slightly higher temperature may add to the comfort. When relative humidity is very high, evaporation from the skin surface may practically stop and cooling by evaporation may cease. Comfort may be obtained at lower dry bulb temperature only by air conditioning.

Air conditioning

During summer, humidity can be reduced by cooling and dehumidification. During winter air may be warmed and humidified by an air conditioning process in which hot water spray of temperature greater than the dry bulb temperature is used. In another process, a preheat coil raises the temperature of the air, an air washer increases the humidity content and the final condition is achieved by a reheat coil which increases the dry bulb temperature. Air washers (Fig. 2) are contrivances wherein air flows through a fine spray of water at the rate of about 150 metre per minute. Water is supplied to the nozzles, meant for spraying and atomizing water, under a pressure of 1.3 to 2 kgf/cm^2.

Water vapour can be removed from air by various methods. Calcium chloride, concentrated sulphuric acid, activated silica gel, alumina and other substances can absorb large amounts of moisture. Absorbents like silica gel can be activated at short intervals by heating to 150 °C. The absorbents, however, are unsuitable for large scale use. Mechanical refrigeration has considerable advantage in that it has a uniform rate of dehumidifying air.

Air can be dehumidified by means of compression with subsequent cooling and condensation of water vapour, and removal of the condensate. This method has low efficiency unless energy is recovered from the compressed air. It has advantages in deep mines where, after utilizing energy of the compressed air, expanded cold air can be utilized for regional cooling. However, mechanical dehumidification cannot reach humidity below 15 per cent.

Humidity control is vital for a number of industrial processes. Textile mills require 50 to 85 per cent relative humidity at 24 to 27 °C. High humidity increases water content of the hygroscopic fibers and improves their pliability and strength. It also reduces static electricity and spreading of

(*Continued on page 429*)

ALTERNATIVES TO THE ENERGY CRISIS

S. RANGA RAJA RAO, SAMIR SEN AND A. LAHIRI

We are faced today with an acute shortage of fuel; diesel, kerosene, petrol, cooking gas and good quality coal. The techniques and processes developed at the Central Fuel Research Institute, Dhanbad, reviewed in this article, if exploited fully, may meet the demand to a larger extent

ENERGY crisis, the talk of the day, has different connotations. While it is mainly restricted to the limited availability of petroleum products, especially gasoline in western nations, in India it assumes significance in a wider sense. The shortage of fuel in the country was never felt so much before as it is today. Industrial sector, be it metallurgical, power generation or transport, as well as the domestic sector are facing the brunt of the shortages. Many activities in these sectors are functioning on reduced scale. Considerable curtailment in rail traffic has been a recent phenomenon.

Domestic consumers today go in for any fuel that is available. In urban areas, the problem of availability of domestic fuels is acute. Kerosene meets only a small fraction of the demand. The popularity of "bottled gas" (LPG) is increasing day by day among higher income groups in cities, but its supply position is becoming more difficult with the passage of time. These shortages may be due to limitations in production, reserves and availability of the right fuels. Any process which holds relief to the present shortage of fuels would be most welcome. In this context, Central Fuel Research Institute's studies and the proposals made by the Institute for the production of industrial and domestic fuels by application of carbonization, pelletization and briquetting techniques to various Indian coals and byproducts of coal processing industries offer possibilities in alleviating the shortages. Also relevant in the present crisis are R & D studies at CFRI on coal and coal products, conversion to gaseous and liquid fuels usable as energy sources for home, industry and as mobile energy.

Synthetic liquid fuels

For the purpose of this review we discuss the energy for transport sector in the first instance, as the energy crisis of the world has been in the true sense only the crisis in the availability of mobile energy and that too with respect to gasoline in western countries. In India, however, where middle distillates of refineries, namely the diesel and kerosene find large use, the energy crisis relates to these products. In a projection made by the Institute (even much before the energy crisis) it was realised that by A.D. 2000 the country would require at least 110 million tonnes of petroleum products of which only a quarter amount may be available indigenously. It is in this context that the CFRI has devoted attention to the development of technological knowledge regarding conversion of the nation's major commercial energy source, namely coal and products derived from it (through processing such as carbonization), into liquid fuels especially diesel, kerosene, aviation fuel and so on demand for which in domestic, transport and defence sectors is continuously rising. Laboratory studies were initiated as early as 1949 and knowledge of catalyst developments, influence of parameters on synthetic fuel production techno-

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Dr. Lahiri is ex-director CFRI, Dhanbad. S/Shri Ranga Raja Rao and Samir Sen are scientists in the same Institute.

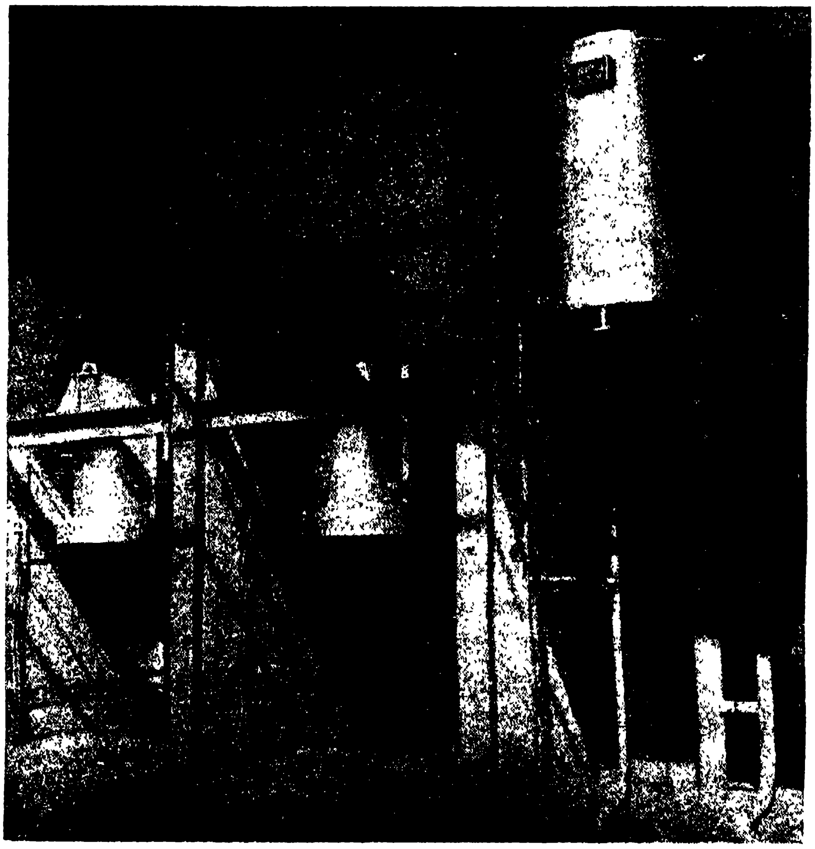

Fig. 1. 100 gals/day synthetic-oil plant

logy, etc., was acquired. These were made use of in the feasibility studies undertaken by the Institute in the mid-fifties for the project on synthetic oil. The Institute has been carrying out investigation through all the three known routes of coal conversion to liquid products, namely, pyrolysis, direct hydrogenation, and through Fischer-Tropsch synthesis.

Pyrolysis

Perhaps the most straightforward route for coal-to-oil conversion is by pyrolysis (heat cracking) whereby coal is decomposed by heating into oil and gases leaving a solid residue as char, semi-coke or coke. Depending on the quality of coal and the method adopted, 50-70 per cent of coal remains as solid residue, the remainder being coal-oils (tar) and gases. Maximum oil yields are obtained by heating coal near its decomposition point between 475 and 550° C in a fluid-bed where instantaneous liberation and removal of oil are possible.

Researches at the Institute on the coals of India showed that there is a basic correlation between hydrogen contents of coal and the oil yields on low temperature carbonization, the maximum oils being obtained from the tertiary coals of Assam. It was also seen that there is a correlation between the oil yields and non-aromatic carbon and hydrogen in coals. These studies indicated that the potential yields of oil by pyrolysis are considerably more than laboratory assay and plant yields obtained, and that maximum oil yields could be obtained by pyrolysing coals in a hydrogen atmosphere (hydrocarbonization). The primary coal-oils obtained by pyrolysis or by hydrocarbonization, however, need further processing by hydrocracking and hydrofining for removing the heteroatoms oxygen, sulphur and nitrogen; for this standard techniques are available in petroleum refining practice.

The very large requirements of smokeless solid fuels for domestic consumption in urban and rural areas of India, currently estimated at 150 million tonne coal equivalent per year, indicate that if it were possible to produce domestic fuels on a very large scale at different centres, the coal-oils could be pooled and hydrogenated to middle distillates (high-speed diesel, kerosene and jet fuels), which constitute the major demand for petroleum products in India. The pyrolysis gases can be used as piped gaseous fuel or for production of hydrogen which has many applications.

Another alternative is to carbonize non-coking coal powders in fluid-bed-suspended powder bed for production of char (which can then be utilised for generation of power) and oils and chemicals. Such a project could be integrated with production of fertilizers from the pyrolysis gases and the char (via gasification). The growth of demand for electricity and setting up of large thermal power plants of say 1,000 MW capacity based on char could yield nearly half-million tonne of coal-oils by techniques of fluid-bed carbonization. Ten such plants could yield about 5 million tonnes of middle distillates (and chemicals), about twice the quantity of what is being currently obtained from indigenous petroleum sources. Careful selection of coals and hydrocarbonization could produce both oil and pipeline quality gas. Such plants would not only be self-sufficient in its own hydrogen requirements, but would contribute to production of fertilizers. Since 30-35 per cent of costs of production of oil from coal is hydrogen, this is an important route to oil and chemicals from coal. It is estimated that even a 10,000 barrels-per-day coal-oil plant by this route could produce about 114 million litres of hydrogen per annum in addition to 100 million kg of ethylene, propylene and butadiene in an all-chemical refinery.

Combustion of char, a major product of the above process, especially high-ash chars, in boilers is not simple. The fluid-bed combustion now under study in several countries and at CFRI holds out promise for utilization of char fines. Much also has yet to be done to develop fluid-bed carbonization to realise its full potentiality, though commercial plants are already in operation.

Tar hydrogenation

Basic work on conversion of primary coal-oils to finished petroleum products by hydrocracking and hydrofining techniques have been studied for some time at CFRI on laboratory and bench-scale. The fact that many of the petroleum crudes and residues can also be so treated for production of fuels to meet specific product demands adds emphasis to this work. The Assam crudes, for example, yield a very poor kerosene and diesel fuel quite unsuitable for normal use and involve considerable loss of middle distillate fractions through sulphur-dioxide extraction. It has been shown by CFRI that hydro-treatment of Assam middle distillates yields superior grade kerosene and diesel oil. Investigations at CFRI have centered around development of catalysts and choice of processing conditions, especially for development of low pressure techniques, with robust catalysts. Pilot plant scale work which alone could give design data will start soon.

Direct coal hydrogenation

The second process for conversion of coal into oil and gas is by direct treatment of coal (or solvent extracts of coal) with hydrogen in the presence of catalysts, which produces a synthetic crude (syncrude) oil. The syncrude, however, has to be further treated by hydrocracking and other established refining techniques. This is the well-known Bergius process for liquefaction of coal used by the Germans during the War. Compared to 7.5-15 per cent conversion of coal to oil by the pyrolysis route, the direct hydrogenation route can result in 40-50 per cent conversion; in other words about 2 tonnes of ashless coal will produce about a tonne of syncrude. This syncrude can then be treated for production either of liquid energy fuels (and gas) or partly energy fuels and partly chemicals, or entirely chemicals.

Researches at CFRI have indicated that the ease of liquefaction of coal and yield of liquid products are a function of its fundamental basic organic chemical structure. Bench-scale investigation of Indian coals has shown that the tertiary coals of Assam are not only the most 'hydrogenable' coals in India, but perhaps, in the world. Therefore, investigations were first taken up on development of catalysts for hydrogenation of these coals. The objective was to develop a cheap and yet efficient 'throw-away' catalyst based on iron, comparable with more active and well-known catalysts like molybdenum, tin, etc. Further work in this field at the Institute relates to the product patterns and refining techniques.

Fischer-Tropsch synthesis

The third route to oil from coal is the Fischer-Tropsch process in which synthesis of hydrocarbons and chemicals is achieved from carbon monoxide and hydrogen (synthesis gas) produced by steam-oxygen gasification of coal or coke. This process has also been investigated for sometime at CFRI and considerable data especially relating to the catalyst have been accumulated which have industrial bearing. Through this versatile process products as diverse as gasoline, heavy waxes, and fatty acids to alcohols, olefines, ketones, esters, and a wide spectrum of hydrocarbons and their derivatives can be produced from coal. One or two plants were erected on this process in Germany during the War, but they were oriented more towards production of chemicals (or feed-stocks for synthetic fibres, polymers, and lubricating oil base stocks and synthetic fatty acids) than toward energy fuels.

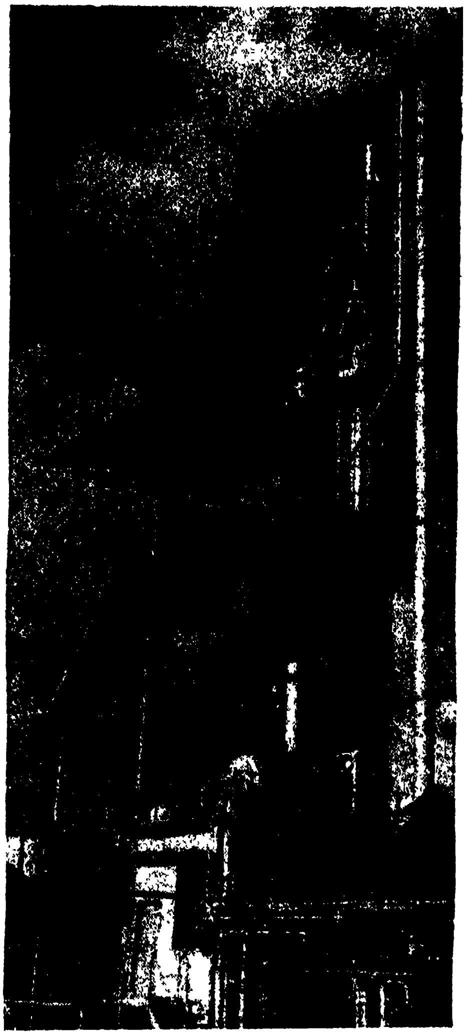

Fig. 2. High pressure gasification plant for producing gas from coal

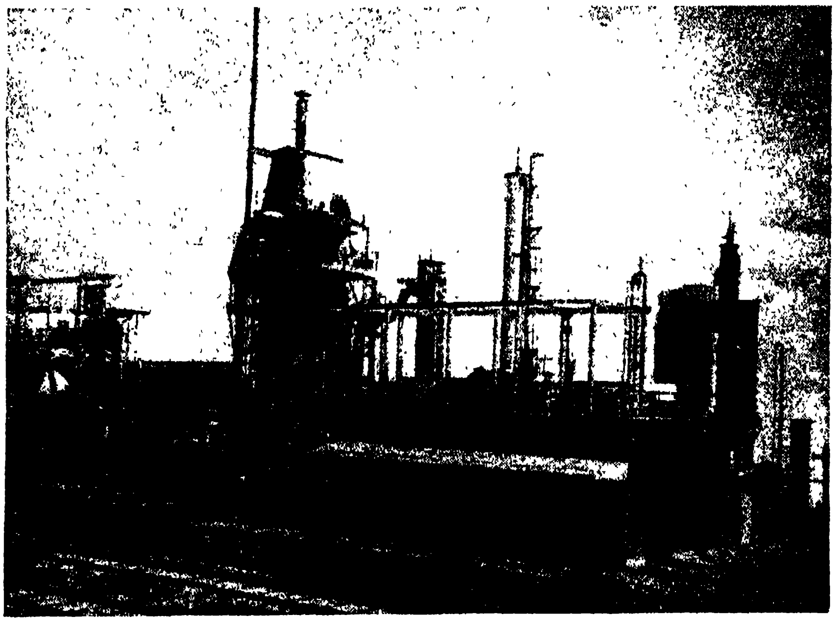

Fig. 3. 20 to 30 tonnes/day low temperature carbonisation prototype plant at CFRI, Dhanbad

Fischer-Tropsch synthesis, which is ideally suited for setting up of a chemical complex based on coal, has been applied on a commercial scale in Sasol in South Africa, currently producing about half a million tonnes of liquid fuels and chemicals besides gas and fertilisers. Originally designed to produce motor fuels and pipeline gas, the project is now oriented to take the best advantage of the potentials of the process.

In 1948 a feasibility study was carried out by M/s Koppers Corporation (USA) for the Govt. of India on production of liquid fuels by F.T. technique in an integrated plant for low temperature carbonization and tar oil hydrogenation. Current economic studies indicate that unless the cost of production and purification of synthesis gas could be reduced appreciably, there is little hope of producing energy fuels only by this route, chiefly due to cost of oxygen and coal. By the process about 5 tonnes of coal yield a tonne of liquid products, of which 30-40 per cent are energy fuels. The potential for energy fuels by this route is, therefore, quite small (only about 10 per cent by weight of coal) though its potential for production of chemicals is perhaps the greatest. Use of byproduct washery middlings, if available at a cheap rate (as may be possible when larger quantities of coal are processed in India for coking), may make the process attractive especially if a cheaper process of synthesis gas production materializes.

Coal for steel industry

For over two and a half decades, i.e., ever since its inception, CFRI has been advocating the cause of coal blending for the production of metallurgical coke in conventional coke ovens. In this, conservation of the limited resources of coking coal (only about 2 per cent of our total coal reserves) and utilization of all available blendable coals have been the guiding factors. The country's steel plants have been greatly benefited by the significant contributions of CFRI for adopting blending technique in their coke ovens for the production of hard coke for steel making. CFRI's studies on selective preparation of coal based on petrographic constituents offer good possibilities for obtaining better coke from the blends and permit inclusion of increased quantities of substandard coking components in the blend.

Processed solid fuel for home and industry

Detailed plans were drawn up as early as 1953 and feasibility visualized regarding the installation of low temperature carbonization plants at suitable locations all over the country for the utilization of large reserves of semi-coking and non-coking coal for the production of industrial and domestic fuels in the form of semi-coke or soft coke, with gas and valuable coal tar as byproducts. The proposition today assumes greater importance in view of techniques developed at CFRI for the conversion of the tar to synthetic liquid fuels like diesel, kerosene, petrol, etc., by vapour-phase hydrogenation. The char from the carbonization plants can be profitably utilized for the production of formed coke employing CFRI technique for briquetting, curing and carbonization. Plans are now on hand at Talcher where NCDC and Industrial Development Corporation of Orissa Ltd. (IDCOL) are jointly venturing into an integrated complex. Besides thermal power generation, the integrated project envisages production of semi-coke by low temperature carbonization utilizing the semi-coke for pig-iron in low shaft furnaces, and also at the same time producing formed coke (350 tonnes per day) by CFRI technique from the char for ferro-alloy industries. Valuable tar and byproducts will also be recovered for sale.

The current energy crisis has led to the consideration of plans for the installation of low temperature carbonization plants in important cities like Delhi, Calcutta and Bombay for supply of both domestic and industrial fuels in the form of town gas and semi-coke. Surveys are being initiated by CFRI for assessing fuel requirements in other major cities also. For instance, under the sponsorship of the Bihar Planning Board, CFRI has started work on a survey of fuel needs of Patna city and suburbs.

CFRI formed coke process. Processes have been developed at CFRI for making hard metallurgical coke from entirely non-coking coals. The low temperature carbonization char produced from these coals is further crushed and mixed with suitable binders (usually processed tar or pitch) and then briquetted using suitable moulds in the briquetting rolls keeping in view their end-use, either for homes or for industries. The briquettes so produced are cured in a curing furnace and finally recarbonized to produce formed coke as a substitute for hard metallurgical coke in industry. The process is also applicable to industrial wastes like coke breeze as raw material.

Moving-grate carbonizer. Under the trade-name "Charminar Koke", a firm in Hyderabad is already marketing a smokeless fuel which is based on a CFRI process. Controlled devolatilization of coals in a chain-grate stoker/carbonizer is the mode of production of the fuel. In this process, sized, weakly caking coals (between 75 and 25 mm) are used. The process is inexpensive since it does not have arrangements for recovery of byproducts; instead the byproducts are burnt with the help of air to provide heat of carbonization for the process, thus saving cost of heating. Such plants can be advantageously established in practically all outlying coalfields.

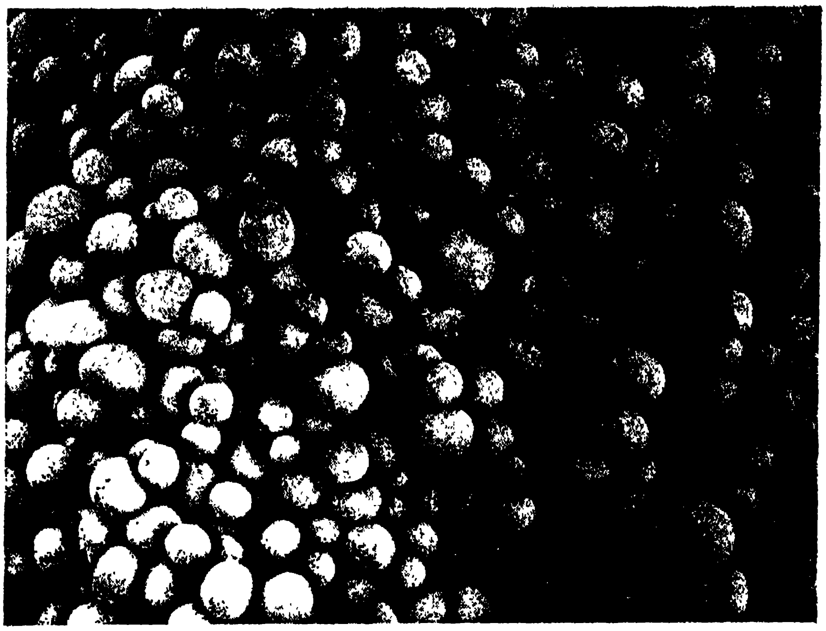

Fig. 4. Pellets (smokeless fuels) produced from washery slurries and byproduct fuels for domestic use

CFRI pellet coke process. For utilization of such low grade waste fuels as middlings, inferior grade coking coals and slacks, the new CFRI pelletization process, in conjunction with the moving bed devolatilizer, can produce an excellent smokeless fuel for domestic and for industrial use. The products produced have been studied in detail about their combustion, handling, storage and other characteristics with excellent results. Plants based on this process can be built on 100 tonnes/day to 200 tonnes/day units. The capital and production cost of the processed fuel are reasonable and a fair margin of profit is possible.

The process consists of powdering the raw materials, mixing them with small percentage of a freely available binder, pelletizing the mixed fines in pelletizer without application of any mechanical pressure in presence of water, drying the pellet and finally devolatilizing the dried pellets on a moving grate carbonizer. The devolatilized pellets are quenched with water.

Attempts are being made to produce a type of spherical formed coke by this technique which may be able to incorporate a large proportion of low-volatile coking coals in blends (now considered unsuitable for metallurgical use) and thus have its application in the metallurgical fuel industry as well. A continuous pilot plant (1 tonne/hr) has been designed and constructed entirely from indigenous sources at the CFRI. Capital costs are considerably cheaper than coke ovens and sub-grade coking coals can be used.

Fuel for power generation

A major CFRI contribution to the fuel and industrial economy of the country has been the introduction of low-grade coals for power generation which, incidentally, has also made possible an offtake for the large production (over 30 per cent) of low grade byproducts of the coal washing plants. In the early fiftees CFRI persuaded the DVC to build the first pulverised low-grade coal burning power station at Bokaro and later at Durgapur. Also, on CFRI's initiative, the Planning Commission and CWPC enforced the use of low-grade pulverised fuel for all future large thermal power plants. Of the coal consumed for power generation today, 80 per cent is based on low-grade fuels with as much as 40 per cent inerts.

A new technique of coal consumption (fluid-bed combustion) now under study at CFRI may enable even 80 per cent ash coal, low-volatile char or coke fines to be used efficiently for power generation.

Future prospects

The role of hydrogen as clean and highly efficient and in some ways versatile fuel is being increasingly realised. Being aware of this, the CFRI has taken up a project on efficient and economic production of hydrogen based on the well-known steam-iron reaction. The novelty now being attempted is to carry out the synthesis at a high pressure which has been evaluated to contribute to considerable economy. Incidental to this study is the discovery of a new source of iron ore (siderite) in the Kutch area of Gujarat State along the lignite field which has been found to be a good substitute for imported spathic iron ore for production of industrial hydrogen. Further work at the Institute is being carried out on generation, storage and transportation techniques related to hydrogen.

The development of fuel cells as energy source is established at least in certain fields such as space exploration. The limitation associated with the fuel cell is the high cost of the gaseous fuel elements in the cells. Attempts of the Institute in this field of study aim at utilization of coal and coal products as the fuel elements.

In the field of combustion, the newly developed technique, namely fluid-bed combustion, has been tested with various high-inert-matter coals of the country and now is being developed so that a prototype of capacity 3000 kg of steam per hour can be established. This technology has immense potentiality in the country due to various technological advantages associated with it, such as use of very high-ash coals.

Studies are also on hand at the Institute relating to the generation of gaseous fuel for use in MHD power generation which is probably the next advancement in thermal power generation. MHD can improve by upto 20 per cent the efficiency of conventional thermal plants which is of the order of 38 per cent. Setting up of a pilot prototype plant unit of 5 MW (by MHD) is under consideration.

To our subscribers

Due to reasons beyond our control the present issue has been designated as September-October 1974. To compensate loss of one issue to our subscribers we have advanced the date of expiry of the subscription by one month.

We hope our subscribers will bear with us.

HOW BODY FIGHTS INFECTIONS

M. P. YADAV AND S. KUMAR

Our body has as many ways of fighting the invading micro-organisms as there are ways for the invaders to get in

THE animal body is continually exposed to a variety of micro-organisms from commensals to obligate parasites. The body fluids generally contain nutrients to sustain profuse growth of many of these species. However, a number of mechanisms operate in the body to eliminate parasites and their harmful products from the system. The resistance against infection may be divided into normal non-specific defences and the specific antibody mechanisms of defence. We will first deal with the mechanism of natural immunity or innate resistance.

Natural immunity

Mechanical barriers. The surface integuments act as important mechanical barriers to the entry of microbes into the tissues. The normal resident flora present in many integuments often help eliminate inimical microbes by production of antagonistic metabolic products.

Skin. In addition to serving as an effective mechanical barrier, the biological activities of the skin help get rid of majority of mircrobes reaching it. The normal microbial inhabitants, viz., *Staphylococcus sp.* and *Propionibacterium acnes* in humans, live and multiply in the ducts, glands and hair follicles and, so, escape the effect of washing and disinfectants. The organic acids produced by resident flora, unsaturated long chain fatty acids from sebaceous glands, and marked acid pH of skin (pH 3.5-5.8), all provide an efficient antimicrobial action. Continuous exposure of the skin to moisture facilitates its invasion by microbes due to softened epidermis.

Mouth, stomach and intestines. Extensive abrasions sustained while eating facilitate entrance of microbes into lymphatics and blood stream. The defence mechanisms in the oral cavity owe to the stratified epithelium which acts as a mechanical barrier. It heals rapidly following an injury. Other factors involved are antagonistic effect of the resident microbial flora, antimicrobial agents (lysozyme, betalysin and lactobacillus bactericidin) in saliva and periodic swallowing of saliva and mucus alongwith particulate matter from base of the tongue.

A proper balance is also essential between various species of normal flora. Often, individuals, receiving a course of penicillin treatment, develop mycologic infections due to *Candida albicans* which is a member of normal flora. This happens due to depletion of another normal flora, *Streptococcus salivarious.*

The microorganisms reaching stomach by way of food or swallowing are rapidly destroyed by the low pH of gastric contents. However, acid-resistant bacteria, e.g., *M. tuberculosis,* and even a susceptible bacterium engulfed in a food bolus may escape the pH action and pass the stomach barrier. In certain conditions, viz., pernicious anaemia and stomach cancer, the stomach itself may act as 'fermentative tank' for bacteria as a result of pH change.

In the intestines the principal defence factors are secretory antibodies (IgA) and the rich microbial flora and mucus. The particles entrapped in mucus are rolled into

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aggregates by intestinal movements and are driven out alongwith the faeces. Phagocytes also play an important role in the antimicrobial defence of the intestinal tract.

Respiratory tract. Most of the inhaled particulate matter is removed from nose by its moist blanket of mucus, tortuous nasal cavity and the air turbulence set up in it by hairs. High concentration of lysozyme, secretory IgA immunoglobulins and other antimicrobial agents present in nasal secretions are the vital agents to protect respiratory tract from microbial infection.

The nasal secretions flow in two directions, i.e., forward to the external nares as a result of ciliary action and backward to the base of tongue from where they are swallowed. The principal defences operating in trachea and bronchi include upward propulsion of the "mucus blanket" due to ciliary action and expectoration or swallowing of respiratory secretions from pharyngeal region. Calling the cough reflex as 'watch-dog of the lung' is highly justified in view of its promptness and efficacy in safeguarding the lower respiratory tract against foreign particulate matter.

Urogenital tract. The low pH of urine and its flushing action during urination safeguard the urinary tract against infection. The possibility of ascending infection is prevented by sphincter controls. Individuals with urinary obstruction are more prone to ascending infection which may reach upto kidneys. An antibacterial agent of unknown nature has been suspected in prostatic secretions of the male which normally reflexes at the bladder on termination of micturition. The normal vaginal flora in women of childbearing age is dominated by *Lactobacillus acidophilus* which keeps the pH low due to lactic acid production.

Eyes and ears. The eyes and its associated structures are provided with highly efficient defence mechanisms. Lacrimal secretions containing several anti-bacterial substances and lysozyme, and flushing action of tears are responsible for relatively infrequent eye infections. The specific defence mechanism of ears is not clear. Probably wax secretion plays some part against infection.

It is extremely difficult to assess the relative protective values of these factors. It is obvious that they often fail. As a result, a small number of microbes usually cross the mucous membranes. However, by virtue of the highly efficient mechanisms of internal defence, the host maintains sterility of its internal compartments.

Inter and non-cellular defence

Phagocytes are the most important inter-cellular defence organelles. They are the 'eating cells' meant for pursuit, capture, ingestion and destruction of microbes. Far flung distribution of these cells in the body fluids and tissue enables the host in clearing the invading microorganisms. The phagocytes include the polymorphonuclear neutrophils (PMNs), large mononuclear leucocytes of blood, peritoneal and alveolar macrophages and fixed macrophages of reticulo-endothelial system (RES), *viz.*, sinusoidal cells of spleen, liver, bone-marrow, lymph nodes, connective tissue histiocytes, microglial cells of brain and adventitial cells of blood vessels. The PMNs are put into action first, followed by macrophages when the former fail to arrest the infection. The circulating PMNs are attracted to the site by chemotactic substances produced as a result of tissue injury. Many microbes are inhibited, killed or digested after their engulfment by phagocytes, but some escape phagocytosis by formation of capsules. Certain pathogens, like tubercle bacteria, have acquired the capacity to survive and multiply within the phagocytes. The macrophages also possess acquired cellular immunity in certain diseases (tuberculosis, brucellosis, listeriosis, etc.).

Inflammation is yet another important defense mechanism against infection and injury. Its various events, *viz.*, accumulation of neutrophils, formation of fibrin network, accelerated seepage of fluid from vessels and consequent extravascular accumulation of macrophages and lymphocytes are responsible for diluting the toxic microbial products and also for providing antibacterial substances. Local changes comprising lowered pH, oxidation-reduction potential, and increased lactic acid and CO_2 concentration create unfavourable environment for the growth of a number of microbes.

The lymphatic system also plays important role in the disposition of locally invading microbes. The draining 'lymph nodes' act as filters or barriers to microorganisms by virtue of their nodal structure and presence of macrophages in them.

Biochemical agents

A number of non-antibody factors are important in developing immunity even before the specific immune mechanisms come into play. For example, the antibacterial activity of lysozyme, an enzyme, is due to its action on muramic acid commonly present in all bacterial cell walls. The lysozyme is less effective against gram-negative bacteria in comparison to gram-positive due to the presence of a rigid mucopeptide cell wall in the former. The combined action of antibody and the complement (a multifactorial serum constituent which precipitates in many antigen-antibody reactions) on outer layers of gram-negative bacteria, however, makes them susceptible to lysozyme action. Significant quantities of this enzyme are present in many human tissues and fluids except urine, sweat and cerebrospinal fluid.

Interferon, a low molecular weight protein, is produced by cells after they are infected with a live or killed virus, or nucleic acid. The interferon, produced within hours after infection with a virus, reaches normal cells and makes them resistant against infection with the same virus and in many cases with certain other viruses too. Efficiency of therapeutic rabies vaccination is based on interference by interferon.

Properdin, a natural antibody with a high molecular weight serum protein, is able to inactivate certain viruses and kill a number of gram-positive and gram-negative bacteria in the presence of complement and Mg^{++} ions. The mucoproteins present in mucus, serum and urine have been shown to inhibit or block cell penetration by influenza-like viruses. Their penetration into cells depends on a viral mucolytic enzyme, neuraminidase. A similar mechanism perhaps also works with vaccinia, mumps and Newcastle diseases. Certain viruses may be neutralized by acid and alkaline phosphatase enzymes.

Beta-lysin, also known as serum bactericidin, is an active agent against gram-positive bacteria. Its concentration in serum is greatly increased during acute infection. Tissue damages and accumulation of fibrin in such places probably activate this system. Many basic polypeptides, namely, leukin and plakin, derived from PMNs and platelets respectively, inhibit and/or kill gram-positive bacteria. Their antibacterial action is perhaps due to the electrostatic binding of positively charged polypeptides to the negatively charged groups on the bacterium.

An antimicrobial system comprising peroxidase, thiocyanate and H_2O_2 inhibits growth of certain microorganisms. The examples are lactoperoxidase in bovine milk, peroxidase in human saliva and myeloperoxidase from PMNs. Thiocyanate is found in extracellular fluids (serum, saliva and milk). Microorganisms which accumulate H_2O_2 due to lack of catalase are inhibited in the presence of peroxidase and thiocyanate.

Antibody formation

Antibodies are produced in the body by specialized cells. Cells of lymphocytic and plasma series which include lymphocytes, lymphoblasts, preplasmacytes, plasmablasts and plasma cells are mainly involved in antibody production. Humoral antibodies produced by these cells are released into the circulation whereas cytophilic antibodies remain in the cell itself.

Antibodies have the unique property of reacting specifically only with the antigen against which they are formed or with the closely related antigen. There are specific reacting site receptors) both on antibody and antigen molecules. The antibodies usually have one (monovalent) or two (bivalent) binding sites but antigens are often multivalent, i.e., they possess several (often heterogenous) receptors. Thus, an antigen may react with more than one kind of antibody. The rate of antibody synthesis is determined by testing the serum of the individuals by serological tests. However, it must be pointed out that serum antibodies only represent released (humoral) antibodies which remain cell-free and hence do not accurately reflect the rate of synthesis.

Several theories have been put forward to explain the mechanism of antibody production in the body but none seems to be an ideal one. When an antigen comes in contact for the first time with antibody-producing cells, a limited population of the latter are induced. Such induced cells are called 'primed' or 'memory' cells. Differentiation and proliferation of the induced cells constitute the primary immune response. The secondary immune response, when the antigen comes in contact with the system for the second time, is often more vital and lasts longer than the primary response. This is perhaps due to the stimulation of 'primed' cells. Probably one antibody-forming cell is capable of producing not more than one or two types of antibodies. It is also believed that one cell perhaps produces antibodies against a single antigenic determinant and that too of one immunoglobulin class.

Animals of most species form little or no antibody in prenatal (before birth) and in early postnatal (after birth) life, presumably because they are immunologically immature. However, the foetal lamb is reported to be capable of producing antibodies from the second month of gestation. Human foetus can also form antibodies after the fifth month of gestation if exposed to strong antigenic stimulation. Antibody producing capacity in men gradually declines after 60 years of age. The foetus and the young ones are protected against infection due to maternal antibodies which may be derived in prenatal life through placenta or yolk sac (in humans and rats) or in postnatal life through colostrum and milk (in calves, pigs, rats and human infants) in which case they are absorbed from the gut. In poultry, the antibodies pass to the newly hatched chick from the egg yolk during embryonic development. The antibodies in egg yolk are stored as a result of transfer from hen's circulation during the 4 or 5 days preceding ovulation.

The homologous antigens and antibodies when placed together *in vitro* under proper conditions of temperature and pH give rise to visible reactions which may be manifested in the form of precipitation, flocculation, haemagglutination, inhibition, immobilization of parasites, lysis, phagocytosis or neutralization of the toxins of the infectious agents. The various antigen-antibody reactions observed *in vitro* also occur *in vivo*. In some instances, however, antigen-antibody reactions prove harmful to the host because of the injury caused to the cells, tissues and organs.

(Continued on page 450)

SCIENCE SPECTRUM

Ionospheric disturbances

ATMOSPHERE — the gaseous envelope that surrounds the earth—extends upto several hundred kilometers above the earth's surface. At altitudes between about 60 km to 900 km, these gases become strongly ionized due to strong radiations coming from outer space and so the region is called ionosphere.

The ionosphere is normally stratified into various layers. The main layers are, *D*-layer (from 60-90 km) which appears in daytime only; *E*-layer (from 100-130 km) accompanied by a sporadic layer in which electron density is always varying; and *F*-layer (from 150-300 km) which splits into two—F_1 and F_2—during the day. Since the main influencing agency is solar activity, the characteristic properties of each layer, namely, height and electron density, are subject to many variations. There are diurnal, seasonal and 11-year cyclic changes due to sunspots. All these variations follow a regular pattern.

Although the study of regular changes in ionosphere is of great practical importance, more interesting is the phenomenon of irregular variations. Only a few theories have been suggested to explain their origin. None of them, however, is perfect. Nonetheless, these variations promise to reveal interesting features of extra-terrestrial universe. The methods of studying the phenomenon are quite simple, e.g., radiowave sounding, spectroscopic studies of aurorae and nightglow, etc. Some of the origins of these abnormalities have been traced to effects of solar flares, meteoric impacts, solar corpuscular bombardment and loose electrons of thunder clouds. But there still remains considerable scope for new theories and, of course, experimental work.

One of the most common phenomena giving rise to abnormal variations is the sudden ionospheric disturbance (or SID). There is a sudden increase of ionisation, especially of *D* and *E* layers with the occurrence of solar flares. This causes weakening and at times complete fade-out of medium and short-wave radio signals over the entire sunlit hemisphere. The fade-out occurs simultaneously everywhere and may last from a few minutes to an hour. This is called Mogel-Dellinger Effect.

Solar flares are also accompanied by small, brief disturbances in the magnetic field. This is called 'crochet.' It indicates that the *D*-layer is more ionized than normal, and hence more conducting. Consequently, much stronger dynamo currents than usual flow during SID.

The disturbances are invariably associated with solar 'eruption' or 'flare' which seems to be their origin. The eruptions occur in chromosphere on sun's surface and send out extreme ultraviolet radiations which penetrate the lowermost layer (*D*-layer) causing increase in ionization.

The frequency of occurrence of SID changes periodically with the 11-year sunspot cycle. SID is also accompanied by ejection of particles, e.g., electrons, protons and other heavy ions which travel to the earth with great velocities ranging from 500 to 2000 km/sec. They reach earth's atmosphere after a time lag of nearly 24 hours behind the radiation waves and penetrate the atmosphere at a belt of 55 to 80 ° geomagnetic latitude, hitting preferably the night side of the earth. Due to their great speed they cause many excitation and ionization processes in the upper atmosphere, causing aurorae polaris and geomagnetic disturbances.

Initially it is the *E*-layer which is most intensely ionized. This layer blankets F_2 layer reflections. The lower edge of ionization further extends into *D*-layer and considerable damping occurs. The complete absorption of high frequency waves is termed as polar blackout.

The disturbance in F_2 layer is rather a complex problem which is not yet understood. Generally the F_2 layer prevails during night which shows that its de-ionization is rather a slow process. So, bodily removal of ions during storms is the only possible explanation for the rapid changes and even disruption which it exhibits during storms. D.F. Martyn of Australia (1953) and T.L. Eckerslay of Britain (1942) attribute this 'removal' to a westward drift motion in two combined fields, one being the earth's magnetic field and the other a vertical electrical field in ionosphere. The vertical field is supposed to be connected with the circular, corpuscular stream round the earth which is formed during magnetic storm. According to Eckerslay, the field is created by separation of different charged particles in ionosphere. For example, a proton with a speed of 3000 km/sec would penetrate upto a height of 83 km (D-layer) while an electron with the same velocity will be trapped at a height of 300 km (F_2-layer). The drift motion will be prevented in lower layers, for density being greater the collision frequency there is higher. Apart from these variations, weak variations occur in F_2 layer much more frequently and usually have a period of 27 days (one solar rotation).

One more interesting field of study is worth mentioning. During a total solar eclipse, the radiations from sun are cut off completely, although only for a few minutes. The process of ionization is shut off and de-ionization can be studied immediately for individual layers. If recombination is intense, instantaneous equilibrium would be achieved and ionization would disappear completely. However, it is observed that recombination coefficient is small and a time lag occurs between the totality of the eclipse and the minimum of ionization. Sometimes the minimum occurs even before the totality of the eclipse. This probably indicates irregular distribution of ionizing radiation over the solar disc. Further, since the effect of solar radiations is predominant in the formation of ionospheric layers and their properties, the effects of extra-solar sources, if any, are normally masked. Careful studies during solar eclipse can reveal the presence and effect of any such agency if it is influential.

Leena Agnihotri
R.S. Prasad

What causes pungency in mustard oil

RAPE or mustard oil which is used extensively as cooking medium in the northern and eastern states of India is easily distinguishable from other vegetable oils by a pungent smell. This pungency is often taken as a sign of purity. This is, however, a misconception. The pungent flavour is due to a group of compounds collectively known by different names—sinigrine, thioglucosides, mustard oil glucosides, etc. They are now termed as 'glucosinolates.' On hydrolysis by an enzyme, myrosinase, they yield glucose, bisulphate, isothiocyanate, or oxazoli-dinethione depending on the parent compound.

Since the first discovery of sinigrine, which is an allyl-glucosinolate in 1840, about ten more glucosinolates have been isolated from different brassica oilseed plants. Any species of brassica may contain more than one glucosinolate. The average percentage of glucosinolates in different mustard seeds ranges from as low as 0.20 per cent to 7.77 per cent. The Indian cultivars usually contain 4-6 per cent of this compound. While extracting oil from seeds the major portion passes intact to the defatted meal and about 5 to 15 parts per million (ppm) remain in the oil if the oil is extracted with solvents. In the press type of extraction there is likelihood of increased amount of this compound getting into the extracted oil.

The glucosinolates as such are not harmful to human or animal health. But if they are acted upon by the enzyme thioglucoside glucohydrolase (commonly known as myrosinase) which is present in the cells of rape and mustard seed, the resultant breakdown product could be harmful in many ways. When the seeds are crushed for extraction of oil and if the temparature is around 40-70 °C with about 13% moisture, the enzyme becomes most active and breaks down glucosinolates. This can be avoided if the temperature is raised to above 80 °C and the moisture content kept around 6-10%. The enzyme can be deactivated by simple heat treatment, steam blanching or immersing the seeds in boiling water.

The intact glucosinolates may break down in the intestinal tract into toxic sulphur compounds. There is, however, no report on the effect of these compounds on human health. Percentage of these compounds can also be lowered by breeding procedures. In the advanced countries, notably Canada, Sweden, Poland, etc., ways have been devised for inactivating the enzyme industrially so that the oil cake can be utilized even for human consumption. Considerable work has also been carried out on the toxicity of the cleavage products on different animals. In India, however, we are yet to make a survey on the content of these compounds in different Indian rapes and mustards.

S.K. Das Gupta

Artificial nodulation in non-legume plants

THE air around us contains 70 per cent nitrogen gas. The atmospheric nitrogen must be 'fixed' before plants can use it under natural conditions. Industrial fixation of nitrogen leads to the production of nitrogenous fertilisers like ammonium nitrate, ammonium sulphate and urea. Ammonia is manufactured by combining nitrogen and hydrogen at 500 °C and at several hundreds of atmospheric pressure with the aid of a catalyst (such as nickel). Biologically, micro-

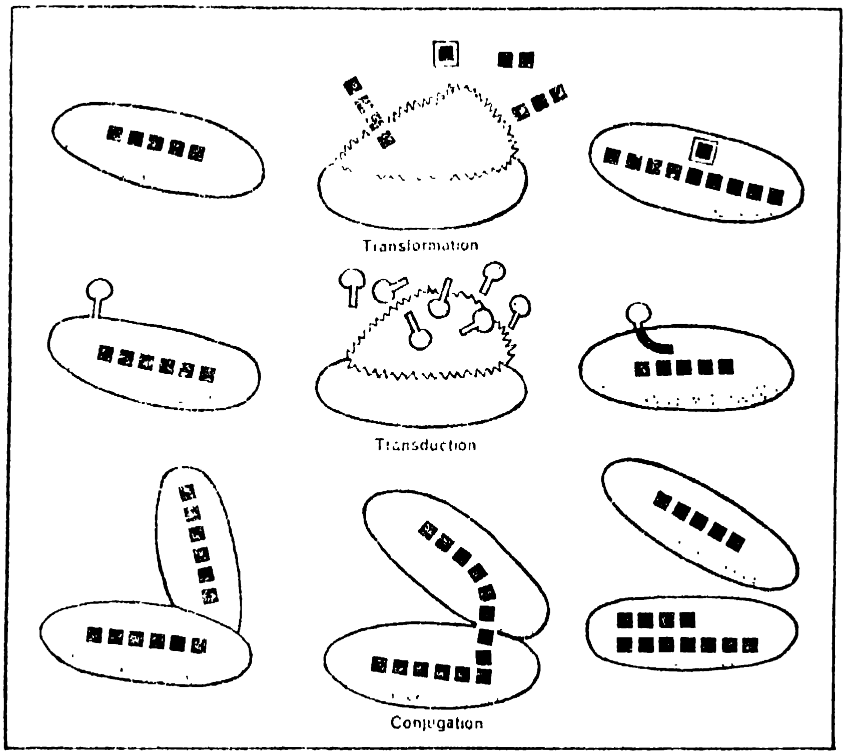


Fig. 1. Methods of transferring genetic material

organisms such as rhizobium bacteria also convert atmospheric nitrogen into ammonia. Ammonia is then turned to amino acids which are the building blocks of protein. This is done at ordinary soil temperatures and pressures through an organic catalyst called 'nitrogenase.' On a global scale industrial nitrogen fixation is about 30 million tonnes per year while annual fixation by rhizobium in root nodules is about 14 million tonnes. There is about 40 million kilogram of free nitrogen in the air above every hectare of land and sea. Out of this the quantity of nitrogen fixed by a hectare of legumes in the growing season vacillates from a few kilogram to 150 kg.

It is possible to increase nitrogen fixation by enhancing it in legumes such as *arhar*, gram, peas and soybean. It is also intended to induce nodule formation properly in the roots of non-leguminous plants, so that even cereals like wheat and rice may fix atmospheric nitrogen. Such a biological inducement to expand and extend nitrogen fixation in pulses and cereals will help bring down the consumption of artificial nitrogen fertilisers. In the face of continued shortage of synthetic nitrogen fertilisers in India, it has become essential to promote biological nitrogen fixation. In this task both microbiologists and geneticists have a pivotal role to play.

According to microbiologists, application of efficient rhizobial culture to seeds is an important factor in any package of practices aimed at producing more pulses and to avoid crop failures. This involves inoculation of seeds artificially. For this, the seeds are washed in water to remove seed coat poisons. Peat or lignite-based rhizobium cultures are made into a water slurry with 5 to 10 per cent sugar (energy source) and 40 per cent neutral, pure, white gum arabic. The gum helps bacteria adhere to the seed coat firmly. The required amount of seeds are placed in a vessel containing the inoculant slurry and mixed with clean hands. The resulting dark coloured seeds are dried on a sheet of paper in shade and sown immediately. The dark-coloured inoculated seeds can be covered (pelleted) with lime and these are suited to acid soils. Pelleting creates a buffer zone preventing inhibitory activity of other soil micro-organisms which minimise the population of rhizobium on seed. Pelleting seeds with lime or charcoal could significantly increase the yields of red gram (*Cajanus cajan*). Soybean responds highly to rhizobium application. Its yields are often doubled since our soils are deficient to specific bacteria capable of nodulating them.

Unfortunately the large-scale utilization of inoculation has several limitations. In India we have no organisation for quality control of inoculants. During summer, cold storage facilities are not adequate. High soil temperatures (about 42 °C) threaten the existence of rhizobia. The cumbersome procedural norms involved in the purchase of inoculants do not facilitate its access at sowing time. To overcome these, alternative experiments are under way. Geneticists are trying to improve the host plant (cereal or legume) to take up and enhance its nitrogen fixing ability. Simultaneously symbionts are being tried for conversion into an active fixer with a broad host range. This research is gaining momentum at the Banaras Hindu University.

Not all strains of rhizobia native to soil are equally effective in nitrogen fixation. Many of them are ineffective. They produce small, whitish, soft nodules which do not fix as much nitrogen as the large, pink and firm nodules produced by the effective strains. Experiments have shown that an active symbiont with a narrow host range and a poor fixer with a broad host range can be genetically manipulated to evolve active nitrogen fixing symbionts nodulating broad spectrum of hosts.

The process of gene transfer can be brought about by transformation, transduction or conjugation (Fig. 1). For transformation a soluble extract of DNA is added from one bacterial strain to another. It causes about 15 per cent cells of the second strain to acquire one or more properties of the first strain. Transformation does not involve a complete substitution of one set of genes for another; only a bit of the total genetic determinants contained in the donor DNA is actually incorporated into the treated cells.

Transduction involves a filterable agent called bacteriophage. A bacteriophage is a bacterial virus which can infect a host bacterium. Ordinarily, this brings about destruction of the bacterium by rapid lysis or disintegration. Subsequently the virus carries genetic material of the disintegrated host to another bacterium through infection. Conjugation involves direct union between donor and recipient bacteria and permits direct transfer of considerable quantities of genetic material and a recombination of genes.

The genetically improved strains of symbionts are then required to be grown in tissue cultures. These can be put to test in the experimental fields to show their new combination of features while nodulating the host pulses, which in turn have passed through genetic improvement techniques. Such a method is likely to fetch enhancement in nitrogen fixation among the pulses.

The feasibility of introducing biological nitrogen fixation in the non-leguminous plants has been quite successful. Here the donor for nitrogen-fixing cells can be non-symbiotic bacteria or algae or even pulses which encourage symbiotic relationship. American scientists at the California Medical Centre have recently succeeded in gene transplanting from completely different micro-organisms to *Escherichia coli* which does not fix nitrogen normally. The gene transplantation is carried out by inserting the desired gene into a certain "plasmid", a small but complete ring of DNA that multiplies only in autonomous condition. The plasmid can be duplicated alongside the relatively huge circular chains of DNA that constitute the chromosome. Plasmid has the ability to form a bridge and inject part or all of a bacterial chromosome into a neighbouring bacterium. It is hoped the method could be used to transfer the ability to "fix" nitrogen from the air into species of microbes living next to the roots of corn and wheat.

Besides intergeneric gene transfer, it has become possible to shift some *E. coli* genes to non-nitrogen-fixing haploid cells of tomato and *Arabidopsis thaliana.* Callus (tissue) cultures of the two plant species were incubated with a transducing phage grown on *E. coli,* pelleted out of bacterial suspension after the lysis was complete. After 2-3 days of incubation, the plant cells showed the activity of the genes under test.

Geneticists at the Banaras Hindu University are proposing to isolate the DNA responsible for nitrogen fixation from blue-green algae and "feed" them to protoplasts of recipient plant species by means of transformation. It is also proposed to develop the technique of selecting and isolating nitrogen fixing cells using cell cultures from pulses. To standardise the technique, transformation will be first attempted within a species of the pulcss. DNA from a 'high fixer' will first be used to transform a 'low fixer'. The DNA from a pulse species may then be 'fed' to protoplasts of non-legume recipients to bring about transformation. Prof. Edward Cocking, M.R. Davey and Eileen Bush of the University of Nottingham, U.K. have isolated rhizobium-infected root cells of the soybean.

Haploid tissue cultures from anthers of non-nitrogen-fixers like rice, tomatoes, tobacco, etc., may be used as recipients, as these plant species are known to regenerate readily. Protoplasts of recipient species will be prepared by using cell-wall degrading enzymes. DNA of different origins—bacteria, algae or pulses—may be 'fed' to these protoplasts. The latter may then be allowed to regenerate cell walls and multiply. The cultures thus established are then tested for nitrogen autotrophs. If nitrogen fixing cells are isolated, they are allowed to proliferate and regenerate plants to ascertain their heredity. The appropriate plants may then be used for genetic and breeding experimentation. Success in such an attempt can lead to nodulation of rice and wheat plants.

K. JOTHI

Energetics of biological nitrogen fixation

IN a simple way, the biological nitrogen fixation can be defined as reduction of atmospheric nitrogen into ammonia under anaerobic or more correctly in micro-aerophilic condition by a variety of micro-organisms. Although reduction of nitrogen into ammonia is an exothermic (energy-releasing) process, the nitrogenase enzyme system for fixation of nitrogen (by generation of H_2) requires energy which is accomplished through the hydrolysis of ATP (adenosine-triphosphate). This energy is known as activation energy.

ATP is a high-energy phosphate compound which serves as a storehouse for the heat energy evolved in the various catabolic processes in the biological system. It is biosynthesized in different manners depending on the kind of microflora, e.g., through phosphoroclastic reaction in case of anaerobic bacteria like *Clostridium* sp., through photophosphorylation in case of cynophyta (blue green algae) and photosynthetic bacteria like *Chromatium* and *Rhodospirillium*, and through oxidative phosphorylation in case of aerobic bacteria like *Azotobacter* and *Rhizobium*, in which the former is a nonsymbiotic nitrogen fixer while the latter is a symbiotic one. The hydrolysis of ATP takes place by nitrogenase in the presence of a reductant (electron donor) like ferredoxin and the electrons donated are transferred to generate H_2 from H^+ (proton) which, in turn, reduces nitrogen to ammonia.

In the absence of nitrogen the rate of ATP hydrolysis and electron transfer continues in the normal way reducing H^+ into H_2 instead of nitrogen into NH_3. It is now known that the number of ATP moles hydrolysed is proportional to the number of electrons transferred, irrespective of the reduction product. Hence it has been an usual way of expressing ATP utilization in terms of electron pairs transferred. Recently Drs. L. E. Mortensen (1966), H.C. Winter and R.H.J. Burris (1968) working at Wisconsin with a partially purified extract prepared from *Clostridium pasteurianum* have reported that for every two electrons transferred or per mole of H_2 evolved or 1/3 N_2 fixed, 4·0 to 4·6 moles of ATP are consumed. It is equivalent to 6—6·9 ATP moles per NH^+_4 mole.

In order to have a better understanding of the energetics of biological nitrogen fixation, it is essential to consider the reactions from the thermodynamic (energy input-output relation in biochemical reactions) point of view. As early as 1947, Dr. P.W. Wilson and Dr. R.H.J. Burris at Wisconsin University studied the thermodynamic aspect of the energetics of nitrogen fixation in *Azotobacter* through some hypothetical reactions, for which the free energy change was examined by an Australian scientist, Dr. N.S. Baylis in 1956. According to them, 578 Kcal energy is consumed for production of 8 moles of NH^+_4, i.e., 72 Kcal net for each mole of ammonia. However, in the cell-free system of *Clostridium pasteurianum*, based on the data of American scientists Winter and Burris (1968), the Australian scientist Dr. F.J. Bergerssen (1971) on the basis of thermodynamic study found that 170 Kcal energy is needed for 2 moles of NH^+_4 or 85 Kcal per mole NH^+_4.

This energy input of 85 Kcal per mole NH^+_4 is in good agreement with that found in hypothetical reactions of Wilson and Burris described earlier. It was also interesting to compare this energy consumption with that used in industrial fixation of nitrogen. It has been estimated that in industrial fixation about 11,150 kwh energy is needed per tonne of NH_3 production which is equivalent to about 163 Kcal per mole of ammonia, about twice that consumed in biological nitrogen fixation. Since in biological nitrogen fixation most of the energy is consumed in the production of H_2 which catalyses the reduction of N_2 into NH_3, it is essentially an exothermic process. This exothermic phenomenon minimizes the consumption of energy as compared to industrial fixation.

In the case of symbiotic nitrogen fixation, ATP is generated through respiratory pathway by the oxidation of glucose in bacteroid tissues. If we assume P:O (phosphate:oxygen) ratio of 2 and the glucose as substrate, the oxidation of each mole of glucose will yield 24 ATP.

$$C_6H_{12}O_6 + 6O_2 + 24\,ADP + 24\,Pi = 6CO_2 + 6H_2O + 24\,ATP$$

As already described, in the case of *Clostridium pasteurianum*, 6 ATP are needed for each mole of ammonia fixation. If we assume this rate in nodule system also, 24 ATP liberated per mole of glucose will produce 4 moles of NH^+_4

$$C_6H_{12}O_6 = 24\ ATP + 4\ NH^+_4$$

i.e., 180 part glucose = 56 part of N. If we assume 100 kg nitrogen fixed per hectare per annum by a legume crop, then

$$\frac{180 \times 100}{56} = 320 \text{ kg carbohydrate}$$

will be consumed. If the total produce of the crop is assumed to be 3000-4000 kg/ha the carbohydrate consumed in fixation will be about 10% of the total produce.

Let us consider this reaction thermodynamically. Fixation of each mole of ammonia requires 85 Kcal energy and it is also known that 1 mole of glucose after oxidation releases 690 Kcal free energy. Thus each mole of NH^+_4 formation will need 85/690 mole of glucose. Thus

for fixing 100 kg N, $\frac{(200 \times 85 \times 180)}{690 \times 14} =$

160 kg carbohydrate will be needed. This will be about 5% of the total produce. This figure is however lower because no account has been taken of the energy consumed in coupling of the energy-yielding reactions. These calculations suggest that fixation by

legumes consumes about 5-10 per cent of the yield. On this criteria, if the apparent increase yield by rhizobium inoculation is 10%, it is actually 20% because carbohydrate equivalent to about 10% of the crop produce has already been consumed during the process of fixation.

B.R. Gupta

Socio-economic progress through research and development

It was not for the technologist to assess his own contribution to economic growth. Perhaps the social scientist would judge it more correctly. However, there cannot be much argument in regard to the immense direct increase in power to satisfy our various wants which is due to technological progress. One has only to travel to some backward village in India where the major operations of agriculture and construction are still done by man or bullock to realize how much we owe to the machine in this respect. Social mobility in society has increased owing to the advent of machines and consequently the appearance of skilled workers. If one accepts the maxim of 'survival of the fittest' one realises how the invention of tools provided the anthropoid apes a means to ensure survival, as observed by Arthur C. Clark in *2001: A Space Odyssey*. However, economic growth means an increasing provision of goods and services to satisfy individual and collective human needs. In the past 150 years, certain areas of the world have seen a steady and substantial growth of production per head of these goods and services, generally accompanied by a steady growth in population. This growth has by and large been followed by a less unequal distribution of wealth among the population, more opportunities and more leisure.

The sociologists may be critical of the leisure that a highly technological society provides. Herbert Marcuse, for instance, has argued strongly against the artificial needs that an advanced technolgogical state generates. In fact one is unable to agree with him, for he has not come up with an alternative model whereby economic growth is achieved without creating these needs.

It must be stressed in this context that an adequate level of research and development and rapid innovation are conditions necessary for economic growth. It will be assumed that other constraints, such as a stable political system, stable means of exchange of goods and services and adequate level of demand for them and above all a system ensuring equitable rewards for productive effort and efficiency already exist.

To say that scientific discovery and innovation are important factors in increasing the productivity of labour is nothing new. Prof. Simon Kuznets has concluded that the sustained increase in the productivity of labour could not have been maintained without continuous innovation, that is, the new application of either old or new knowledge to production processes. Since the possible uses of old knowledge were limited, continuous innovation required continuous new addition to knowledge. Many of the industries now important in the industrially advanced countries have become increasingly dependent on discoveries made by trained scientists and engineers, and on the regular and systematic exploitation of them.

In advanced countries, entrepreneurs have seen from past experience that innovation based on scientific discovery can be profitable, and the widening boundaries of science have given them more and increasingly powerful tools with which to manipulate their physical environment and to create and improve products and production processes. Also, with increasing industrial activity it has become possible for a separate research and development organisation to emerge. The latter, in turn, by its new innovations feeds back to the industrial sector. Industries which are able to exploit scientific knowledge are growing rapidly, and hence adequate expenditure on research and development is a necessity, though it is not a sufficient condition for growth. In India the industries spend but a negligible fraction on R & D and consequently they have in general to rely on imported know-how. This is one of the many reasons for our lagging behind.

That research and development influence the rate of industrial growth has been well established. Over the past 25 years in the industrial sectors of the U.K. and U.S.A. which have spent large funds on research and development in relation to net output, total production has grown rapidly and labour productivity has reached correspondingly high levels.

The prospects for accelerating economic growth by tapping technology are quite promising. Contemporary mankind uses energy equivalent to that of a billion tonnes of coal annually. Therefore it would appear that the available resources would be depleted in a few centuries. Although it may appear too speculative to think of the year 2500 A.D., it would appear that as centuries pass man will resort to more and more technology. For instance, technological skills will enable him to seek resources outside this planet.

At present the technological affluence is limited to the industrially advanced nations of the world. The eminent theoretical physicist Dyson conceived of the possibility that man may harness the energy of the sun by transporting extra-terrestrial matter to form an artificial shell around the sun. This artificial earth will provide enough energy for far more humans than is possible today. The exploitation of underground nuclear explosions shows the way for construction of canals which would otherwise have not been possible. In arid regions like deserts the technique may open up prospects of extensive cultivation.

Thermonuclear fuel will facilitate further release of electricity from heat. There is the possibility of electrifying rural areas from thermonuclear fuel which, being hydrogen, is plentiful in the earth's oceans. The English clergyman, Malthus, predicted a day when population will outstrip production and this fear led to his despondent view that the working class would have to reduce their birth rate drastically in order to survive. Yet one need not share this gloom for, surely, the intelligent technologists of tomorrow should be able to counteract such Malthusian forces.

In the West, except for space and nuclear research, most of the work is sponsored by the industries themselves. In India most of it is done on government expenses. Industries spend but a negligible fraction of their budget on research and development; there is no indigenous innovation. This in effect makes industry heavily dependent on foreign ideas as pointed out earlier. In view of the sceptical outlook of most Indian industrialists, especially regarding the profitability of investment in research and development, an adequate level of expenditure in this direction cannot be expected in the absence of Government encouragement and fiscal incentives.

What can statistics tell us of the extent to which technological innovation and research and development have influenced rate of economic growth? The importance of innovation has been confirmed by a series of studies undertaken in the United States which show that only about one half of the growth of labour productivity over the past fifty years can be explained by the growth of the amount of capital per worker and by the allocation of labour and capital. R & D did the rest.

It is self-evident that the educational system should provide an adequate number of qualified scientists and engineers to undertake research and development for economic purposes. It also requires, in many countries, that more persons of outstanding talent investigate problems of applied science and engineering as shown clearly by the example of a country like Sweden, where industry is very responsive to the economic possibilities of technical change, and is conscious of the real value of undertaking research and development. This is largely because of the high academic and professional reputation of the Swedish institutes of technology, the entrance requirements of which are highly competitive, and the graduates of which are heavily represented among the leaders of Swedish industry.

Fundamental research is assuming increasing practical importance, mainly as a result of the advances in the military, space and industrial fields. Oriented fundamental research is therefore being undertaken in industrial, governmental and university laboratories. In the United States, the growth of oriented industrial contracts with the universities has been particularly rapid. It is clear that Government should help ensure that industries have fruitful contracts with the universities in respect of oriented fundamental research also.

S. SUBRAMANIAN
R.R. SUBRAMANIAN

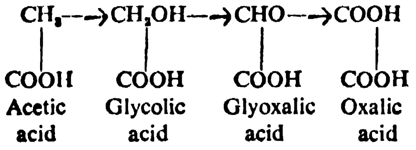
Harmful effects of oxalic acid

THE toxic nature of oxalate ion has been well recognised for a long time. Oxalate-bearing plants are world wide in distribution. Salts of oxalic acid are found in leaves of these plants and may account for 10 to 30 per cent of the dry weight of the plant. However, a few plant species have an oxalate concentration high enough to be acutely or sub-acutely lethel when ingested by animals. These include sorrel (*Rumex acetosella*), greese wood (*Sarcobatus verniculatus*), saursob (*Oxalis cernus*), rhubarb (*Halogenton glomerulatus*), etc. Oxalate is also present in large number of Indian fodders, chunking foods, vegetables and fruits, spinach, sugarbeet and other feeding stuff.

Free oxalic acid rarely occurs in plants and, if present, barely in a measurable amount. The acid-soluble oxalate represents the total oxalate content. In the soluble form it is generally found as sodium and potassium oxalate and the water-soluble fraction (WSO) mostly represents potassium oxalate (80%). The bound oxalic acid or the insoluble oxalic acid (total-water soluble oxalates) represents the fraction which is largely as calcium oxalate, but it also forms combination with magnesium to some extent. However, the WSO fraction is more important from toxicity point of view.

Synthesis and metabolism

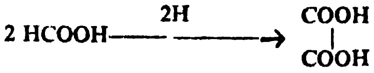
Oxalic acid accumulates in large quantities in certain plants, but it is not known with certainty how it does. It may originate from the oxidation of a large number of compounds, namely, sugars, amino acids, alcohols and carboxylic acids. The formation of the acid from C_5 to C_6 monosaccharides is probably due to the combined oxidation and splitting of the first two carbon atoms (counted from the aldehyde group). The most probable pathway for its formation starts with acetic acid and involves the step-wise oxidation of acetic acid to glycolic acid, glycolic acid to glyoxalic acid and finally to oxalic acid. The course of reaction is represented as follows:



$$\begin{array}{cccc} CH_3 \rightarrow & CH_2OH \rightarrow & CHO \rightarrow & COOH \\ | & | & | & | \\ COOH & COOH & COOH & COOH \\ \text{Acetic acid} & \text{Glycolic acid} & \text{Glyoxalic acid} & \text{Oxalic acid} \end{array}$$

Oxalic acid may be formed from other compounds which participate in the citric acid cycle and these include oxaloacetic acid which can break-down into acetic acid and oxalic acid, and isocitric acid which can be split by the action of isocitratase to yield succinate and glyoxalate. Glyoxalate, in turn, can be oxidized to oxalate and oxalosuccinic acid which can be hydrolysed to succinic acid and oxalic acid.

Oxalic acid may also be formed by condensation of two acetic acid molecules to give succinic acid which is subsequently converted by a sequence of reactions to fumaric acid, malic acid, oxaloacetic acid and finally to oxalic acid. Condensation of two molecules of formic acid gives rise to oxalic acid, the conversion being catalysed by formate dehydrogenase.



$$2\,HCOOH \xrightarrow{2H} \begin{array}{c} COOH \\ | \\ COOH \end{array}$$

Oxalic acid has been considered to be a waste product and not a participant in metabolism. This view is, however, contradicted by other evidence. It has been suggested that oxalic acid is translocated from the root store to leaves of *Rheum hybridum* in the spring and later in the year the reverse may take place. An enzyme, oxalate-oxalase, which further brings about metabolic transformation in oxalic acid occurs in many plants. It catalyses the reaction:

$$H_2C_2O_4+O_2 = H_2O_2+2CO_2$$

It may be decarboxylated in higher plants such as sunflower and sugarbeet leaves to CO_2 and formic acid in an enzyme system requiring ATP, coenzyme A and Mg^{++}. The reactions involved can be described as under:

Oxalate coenzyme A $\xrightarrow{Mg^{++}+ATP}$ Oxalyl coenzyme A

Oxalyl coenzyme A $\longrightarrow$ CO_2+formyl coenzyme A

Formyl coenzyme A $\longrightarrow$ Formic acid+coenzyme A

Variations in content

Generally oxalic acid content depends upon the species and varieties of the plant, soil, nutrients, light intensity, temperature, season and environmental factors. But in the case of spinach it is believed that environmental factors—soil moisture, light intensity, rate of growth and time of harvesting have little effect on its oxalate content. High oxalate content of spinach is an inherent physiological characteristic of this plant. It is found from very negligible to very significant quantities in different feeding stuffs such as paddy straw and napier grass. Fresh plants show high concentration of oxalate than the dried one and the content also depends upon the method employed for its determination.

Root tops, sugarbeet, fodder sugarbeet and fodderbeet on an average contain 7 per cent oxalates of which about half is water extractable. The total oxalate content in cereal grains and their products varies from nil to 0.21 per cent, in pulses and legumes from nil to 0.42 per cent, in leafy vegetables from nil to 1.68 per cent, in roots and tubers from nil to 0.04 per cent, in nuts and oilseeds from nil to 1.70 per cent, in condiments and spices from nil to 0.06 per cent, and in fruits from nil to 6.22 per cent. In wild and edible plants, the soluble oxalate varies from 12 to 80 per cent of the total oxalates. In grasses, the acid-soluble oxalates range from 0.33 to 3.08 per cent, whereas the water-soluble oxalates vary from 0.06 to 1.95 per cent with a significant positive correlation existing between them.

Toxicity

The lethal dose of oxalates for man is believed to be about 2 gm and for cattle about 40 gm per day. Cases of death of infants caused by eating rhubarb leaves or spinach have been reported. The mode of absorption and metabolism of oxalates vary in different species of the animals. In the case of non-ruminants oxalic acid is not degraded but in ruminants the ingested oxalic acid, mostly as potassium oxalate, is degraded by the action of rumen microflora to alkaline carbonates and bi-carbonates which produce in the animal body a severe form of alkalinity which indirectly interferes in calcium assimilation and is also responsible for disturbing the calcium equilibrium. The insoluble oxalates are not broken down in the rumen and are quantitatively excreted in the faeces without taking part in metabolism. However, reports in the literature suggest intestinal breakdown of oxalates. A level as low as

2.42 per cent is known to produce deleterious effects in cattle. Since the oxalic acid content of grasses is low, it is presumed that no deleterious effect of any kind will be produced in animals. However, oxalic acid level of 4 per cent or above in grasses is considered toxic or even fatal to cattle when the cattle graze heavily on grasses particularly under condition of starvation.

Other effects

A high content of oxalate has been regarded as a negative quality factor in leafy vegetables especially when the latter are consumed in large quantities. It interferes in the utilisation of dietary calcium and magnesium in the digestive tract and is involved in the formation of urinary calculi, oxaluria and oxalemia. Prolonged use of oxalate-rich foods has experimentally been shown to induce hypocalcaemia, rickets, deposition of calcium oxalate crystals in kidney, illness, diarrhoea, nervous symptoms and finally death. It causes decalcification in ruminants due to the high concentration of certain cations which remain after destruction of oxalate ion; and in simple stomach animals by the precipitation and excretion of calcium oxalate. The degraded products of oxalic acid, viz., carbonates and bicarbonates give rise to alkaline pH in the rumen which indirectly interferes in the absorption of calcium through the gut of the animal. Paddy straw or similar fodders containing soluble oxalates induce severe form of alkalinity.

Methods of detoxication

A number of experiments have been conducted for minimising the toxic effects of oxalic acid. Suitable processing of the straw can prevent the ill effects of toxic ion. Water washing removes soluble part to some extent. Supplementation with calcium to neutralise the effect of oxalic acid has been used extensively in acute oxalate poisoning. Feeding of concentrate has also been reported to reduce the risk of *ad lib* feeding of hybrid napier to growing cattle. When other vegetables, feeds, fodders, cereals, pulses and fruits are available, it is beneficial to avoid eating oxalate-rich material, or such foods may be supplemented with extra source of calcium.

Since people of our country and animals derive most of their mineral and vitamin requirements from vegetable products and green fodders respectively, it is important that sustained breeding programme for varieties low in oxalic acid should be carried out. Progress in this line of investigation will control the adverse effects of oxalic acid and will encourage the use of oxalate-free plants for ruminants and non-ruminants.

D.R. Sood
D.S. Wagle

HOW BODY FIGHTS INFECTIONS

(*Continued from page 441*)

Altered immunoglobulin syntheses, i.e., deficiency globulinemias (as in hereditary agammaglobulinemia or acquired agammaglobulinemia appearing in certain idiopathic diseases, excessive protein loss in nephrosis, hypercatabolic states, malnutrition and lymphoid neoplasia), dysgammglobulinemias (abnormal production of one or two immunoglobulin classes) and hypergammaglobulinemias (due to strong antigenic stimuli, trypanosomiasis (IgM antibody), rapid hepatic regeneration following liver injury or neoplastic diseases of antibody-forming cells) are often the consequences of diseased state, or reflect the increased susceptibility to certain infections.

Vaccination also induces an animal to produce antibodies. Efficient and properly balanced immunoglobulin synthesis is essential for the protection of the body against harmful, infectious agents. The antigenic stimulation should give a greater and persistent antibody response for an effective and lasting immunity.

Further readings

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NEWS & NOTES

CSIR programme for study of science, technology and development

THE Council of Scientific and Industrial Research has initiated studies on the role of science and technology in the process of development as a part of the activities of the Planning Group at the CSIR Headquarters. A nucleus group has taken up various aspects for study. The studies seek to throw light on the basic problems involved in the planning of science and technology for national development.

As part of this effort is an Information Unit entrusted with the task of collecting and disseminating information on science policy in developing countries. The Information Unit has been set up on the specific recommendation of the International Summer School organised by the CSIR in cooperation with the International Commission of Science Policy and with the active help of UNESCO. The studies undertaken are guided and supervised by an Advisory Committee headed by Dr. Y. Nayudamma, Director-General, CSIR.

A core faculty of research fellows is working on the problems of inter-play of science and society, historical and social dimensions of science and technology between the advanced and developing countries and the consequent problems of transfer of technology. Prof. A. Rahman heads the faculty.

Opportunities are provided to scientists both from India and overseas countries who would like to avail of the facilities available and carry out studies on any of the areas delineated by the Advisory Committee. There are a few fellowships for visiting scientists and research associates who would like to work for a year or two. In addition, those scientists who have their own fellowships would also be provided by the necessary facilities for study.

Associate scientists may take up problems of research in identified areas of interest as part of collaboration between the CSIR and the institution where they are working. CSIR may give them grants for the conduct of such studies.

Major areas of study which have been delineated at present and are being emphasised are:

1. *Alternative technologies:* Studies directed to develop technologies to suit social, cultural and economic conditions of developing countries and aiming to avoid the deleterious effects of existing technologies.
2. *Planning of science and technology:* Studies aimed at developing philosophical concepts, defining social framework, developing techniques and tools for planning, monitoring and evaluation of research.
3. *Dynamics of science, technology and society:* Studies directed to throw light on social, cultural, and human implications of scientific and technological advance, technology assessment, political and economic factors affecting the relationship between science and technology of the advanced countries with those of the developing countries and other related problems.
4. *Scientific and technical manpower:* Studies on the relevance of education to the needs of society, problems of unemployment, malemployment and brain drain, role of scientific community in society, creativity and research productivity and other related problems.

In addition to the above four major areas of work, some studies on the historical development of science and its social role in different societal, cultural and national contexts may also be taken up.

Salt industry and scientists: get-together at CSMCRI

THE third get-together of salt industry and scientists was organized by the Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar on 11 and 12 July 1974 at the Institute. The get-together was divided into two technical sessions on the first day, followed by discussions on the second day.

At the first technical session, papers were presented on the following topics: (1) Main achievements of the experimental salt farm during 1972-73; (2) Rain-washing of common salt heaps; (3) Processes and equipment used for large-scale washing of salt in other countries; and (4) Mechanization in salt industry. With regard to the improvement of the quality of salt produced at the experimental salt farm, participants pointed out difficulties in adoptng series feeding system on a large scale. Though the natural rain-washing helps in upgrading the solar salt, the participants felt that there was need for working out an artificial method.

To increase the productivity of salt works, mechanization of several operations, viz., soil stabilization, pumping of brine, salt harvesting, stacking, grinding, etc., was suggested. Participants expressed the need for designing and fabricating a suitable mechanical salt harvester. This work has already been included in the R & D programmes of the Institute.

In the second session, papers on marine chemicals, viz., (1) Recovery of potash by solar evaporation, (2) Mixed salt for potash fertilizers, (3) Recovery of potash fertilizer from Kharaghoda mixed salt, (4) Revised cost estimates of potassium schoenite, and (5) Sea-water magnesia technology were presented and discussed. The Chairman of this session stressed the need for recovery of potash fertilizers from bittern as an import substitution product. Further, sodium sulphate being one of the by-products in the recovery of potassium chloride from mixed-salt, and owing to its present high selling price, there is additional attraction for establishing plants for potassium chloride recovery. Similarly, with comparatively smaller initial capital investment it is possible to establish plants for the recovery of potassium as potassium schoenite with good return.

The progress in the R & D work on the production of refractory grade magnesia on a pilot plant scale was dealt with by the scientists working on this project.

On the second day, problems posed by salt works and the Salt Manufacturers Association were answered by the scientists. While examining the possibility of lay-out of a large salt works, of about 10,000 acres, several difficulties like transportation of salt, heavy loss of salt and deterioration of the quality of salt due to sand-storms were brought to focus. Some participants pointed to the need for establishing salt-based industries near large salt works.

After a group discussions on potash, at which emphasis was laid on the recovery of potassium fertilizers from the Gujarat Salt Works so that considerable foreign exchange could be saved, the get-together recommended the formation of a committee consisting of the representatives of salt manufacturing industries, the Government of Gujarat and the Director of CSMCRI which would give suggestions to the Gujarat Govt. in this regard.

In the group discussion on the recovery of bromine from bittern, participants inquired whether high-density bitterns containing higher percentage of bromine could be utilized. It was explained that the use of high-density bittern may choke the tower. It was also suggested that chlorine, generated at the site, would be convenient and cheaper. Electrolysis of magnesium chloride to produce chlorine was suggested. Further work on this project could be taken up by CSMCRI.

Role of computors in structural analysis, design and optimisation: Seminar at NAL

THE second seminar on Role of Computers in Structural Analysis, Design and Optimization was held at the National Aeronautical Laboratory (NAL), Bangalore, on 13 June 1974. The first seminar on the subject, held at IIT, Madras in 1972, was instrumental in drawing attention to the subject of computer-aided design, analysis and optimization in various fields including civil engineering, mechanical engineering, and aeronautical engineering. It was also emphasized that periodic seminars of this kind would not only enable scientists from different organizations to meet and discuss the latest trends but also promote the larger use of scientific methods for complex problems faced in the field of design and optimization.

Dr. S.R. Valluri, Director, NAL, said in his inaugural address that the seminar was important in the context of increasing attention being given to the use of computer-aided design not only in aricraft structural analysis and optimization but also in various other engineering applications. He drew attention to the efforts of NAL in realizing a Regional Computer Centre for helping computer-aided design for the industries and educational institutions located in the Bangalore region. The Govt. has approved three such centres; one to be set up at the Tata Institute of Fundamental Research, Bombay, the second at the Jawaharlal Nehru University, Delhi, and the third at Bangalore. Dr. Valluri stated that the primary thrust at the Bangalore centre would be the development of computer-aided design and design automation.

There were also special lectures on "Computers for real time applications" and "Application of digital computers in vibration testing and analysis."

MEDICAL NOTES

Vanadium—a new essential trace element

A CONTINUOUS set of eight elements in the first series of transition elements of the Periodic Table, from vanadium to zinc(V, Cr, Mn, Fe, Co, Ni, Cu, Zn), has been of much importance to the biologists. Although the presence of vanadium in the living beings is long known and by 1960 its essentiality in the plants was recognised, the data supporting the view that vanadium is an essential element for animals was first reported by L.L. Hopkins, Jr. and H.E. Mohr (*Newer Trace Elements in Nutrition*, ed. W. Mertz and W.E. Cornatzer, New York, Mercel Dekker, 1971 p. 195) in 1971. The initial finding was a significantly reduced growth of wing and tail feathers in chickens maintained on a vanadium deficient diet. Reduced body growth was reported by K. Schwarz and D.B. Milne in rats consuming diets low in vanadium (*Science*, 174, 426, 1971).

Vanadium has been shown to play an important role in lipid metabolism; continued deficiency of the element leads to the increase of plasma cholesterol (F.H. Nielson and H.H. Sandstead, *Amer. J. Clin. Nutr.*, 27, 515, 1974) and triglyceride levels (L.L. Hopkins, Jr. and H.E. Mohr, *Fed. Proc.*, 33, 1773, 1974). Both in rats and chickens low vanadium diet raises the hematocrits of the blood. The iron content of the blood and bone is also significantly increased. When radioactive vanadium is injected into animals, the highest uptake occurs in areas of rapid mineralisation in the dentine and bone. Localisation of vanadium in the tooth structures supports the view that the element might play a role in dental caries. Reproductive performance of rats taking a diet of less than 10 p.p.b. vanadium was found to be reduced slightly in the third generation and markedly reduced in the fourth generation in which the incidences of stillbirths and mortality of the pups were high.

Vanadium deficiency has also adverse effects on bone development in the chick (F.H. Neilson and H.H. Sandstead, *Amer. J. Clin. Nutr.*, 27, 515, 1974). Histologically, the tibia of the deficient animal shows severe disorganisation of the cells of the epiphysis. The cells appear compressed with flattened nuclei. The abnormalities result in shortened and thickened leg structures. Thus, the results of various studies on two species, rat and chicken, indicate that vanadium participates in several important physiological functions, namely, body and feather growth, lipid metabolism, hard tissue metabolism, blood cells and iron metabolism. and reproductive performance. Although, naturally occurring vanadium deficiency in man and animals is yet to be demonstrated and the level of the dietary need of the element is not precisely established in different species, the recent evidences strongly suggest that vanadium should be considered as a new essential trace element for higher animals.

B. Pal

Cultured cells synthesize antibodies

A GROUP of scientists in Boston area have recently presented evidence that they were producing antibodies in cultured cells derived from rabbit's spleen and are hopeful that they would be able to develop a way of producing a steady supply of antibodies for basic research and immunotherapy. The scientists are Drs. A.D. Strosber, J.J. Collins, P.H. Black, D. Malamud, S. Wilbert, K.J. Bloch and E. Harber of Boston's Harvard Medical School and Massachusetts General Hospital. They developed cultures of antibody-producing cells by several steps (*Proc. Natl. Acad. Scis., U.S.*, 71, 260 and 263, 1974). They immunized a rabbit against pneumococcal vaccine capable of causing bacterial pneumonia and grew cells from the rabbit's spleen in laboratory tissue cultures. They exposed the cells to a virus called simian virus 40 (which is known to cause cancer in some animals) and transformed some of these cells into a cancer-like state in which the cells grew and reproduced indefinitely. One derivative of these cells reproduced and synthesized antibodies (immunoglobulin G) against the pneumococcus to which the rabbit had originally been exposed. They have been producing these homologous antibodies from these transformed cultured cells for more than a year. This is perhaps the first case where specific antibodies are synthesized outside the host-body.

R.K. Datta

Use of methotrexate and citrovorum in bone tumour

AT the American Cancer Society's Science Writers Sessions recently held at St. Augustine, Florida, Dr. Emil Frei, Director of Children's Cancer Research Foundation in Boston, reported effective treatment of children's bone cancer (osteogenic sarcoma) with very large doses of highly toxic anti-cancer drug, methotrexate, followed by another chemical, citrovorum factor, that rescued normal non-cancerous cells from methotrexate's devastating effects (*New York Times*, March 24, 1974). According to his report, 17 children with bone tumour, who had been given the drug-rescue treatment during the last 21 months, were all alive. Normally, bone tumour is fatal in 80% of its victims within a year. Among adverse effects, only one patient had the spread of the disease. None suffered serious damaging effects from large doses of methotrexate. Though methotrexate, a close chemical analogue of vitamin folic acid, has been used since fifties against a variety of cancers, its use is limited for its damaging effect on normal cells. As a mode of action, methotrexate is said to trick cells, most particularly the rapidly dividing cancer cells, into thinking it was the essential vitamin folic acid, and the lack of real folic acid prevents the cells from dividing, thus causing their death. As stated above, methotrexate also kills normal tissues that contain rapidly dividing cells. In early sixties, Dr. Issac Djerassi of Mercy Catholic Medical Centre of Darby, Pennsylvania, started using citrovorum factor as an antidote to protect normal cells from total devastation in methotrexate therapy. Citrovorum factor, an active form of folic acid, is believed to protect, by some unknown mechanism, normal cells preferentially from the effect of methotrexate.

BHAKTI DATTA

Enzymatic defect in phytanic acid storage disease localized

REFSUM disease or phytanic acid storage disease is a hereditary condition characterized by chronic polyneuritis with weakness and wasting, inflammation and pigmentation of retina, progressive deafness, ache, and scale formation in the skin. In an attempt to pinpoint the enzymatic defect that leads to the storage of phytanic acid, Dr. D. Hutton and his associates of the University of California at San Diego demonstrated recently that the oxidation of ^{14}C-(uniformly labelled)-delta-hydroxyphytanic acid into ^{14}C-carbon dioxide and of (9, 10-^{3}H)-palmitic acid to ^{3}H-water was normal in fibroblast cultures derived from five chemically documented cases of phytanic acid storage disease (*Neurology*, 23, 1333, 1973). These cell lines were shown previously to oxidize ^{14}C-(uniformly labelled)- phytanic acid itself at only 1% of the normal rate. Thus, the metabolic error in these cases presumably lies in the introduction of the hydroxyl group into the delta-carbon of the phytanic acid. These investigators found a total of eight cases of phytanic acid storage disease to be defective in the delta-hydroxylation reaction and supported the generalization that a single, common mutation underlies the metabolic disturbance in patients with Refsum disease.

BHAKTI DATTA

BOOK REVIEWS *(Continued from page 458)*

The author, who is also a popular science writer has succeeded in making this volume readable, and even a lay reader will find some things of interest and be able to understand the rudiments of the chemical properties of textile fibres and the processes of their manufacture. The book can well serve as a ready reference book to those working in the textile industry. But even more it would be a very good book for students of textile chemistry in the early stages of their study.

The get up and printing leave little to be desired.

The author has indeed succeeded in his aim and gives us in simple language the basic concepts of the chemistry and production of textile fibres. If his succeeding volumes live up to the promise of this, the first, they may well earn the distinction of being a standard text on the subject.

E. D. JAYARAM

SCIENCE FOR THE YOUNG

Metric units through the ages

THE measurement of time was not known to the early man, or, if known, was lost through the ages with the passage of time. They reckoned time on the duration of the earth's rotation on its own axis (doin or day), the moon to revolve once round the earth (Lunation or lunar month) and the earth to revolve once round the sun (Tropical year).

The ancient chronology on time measurements reveals that the Chinese used a clypsydra as early as 4000 B.C. (close to the start of Hindu *Kaliyuga*). Sundials were used in the Euphrates valley in about 2000 B.C. An Egyptian sundial is believed to have been preserved in the Berlin Museum which dates back to 1500 B.C. Towards about 1000 B.C., it was common in China to use candles made of sawdust and pitch marked at intervals to indicate passage of time. The unburnt portion indicated the duration of doin left. The first clypsydra is believed to have reached Rome by 159 B.C.

The records available in old Hindu scriptures indicate that a system of sub-divisions of the day existed in ancient India which was astonishingly perfect. Lagadha, a celebrated astronomer who lived somewhere in the Kashmir valley, introduced the *Vedanga Jyotish*in 920 B.C. according to which:

1 *Savan day* = 30 *Mahurats*
1 *Mahurat* = 2 *Nadika*
1 *Nadika* = 10½ *Kala*
1 *Kala* = 124 *Kastala*
1 *Kastala* = 5 *Akshara*

Also,

1 *Savan day* = 603 *Kala*
1 *Tithi* (Lunar day) = 513 62/17 *Kala*
1 *Naksatra* = 610 *Kala*

The division of a day into subunits of 60s as found in the ancient astronomy was probably based on the convenience and ease of multiples/sub-multiples in location of star positions. The figure 60 being exactly divisible by 2,3,4,5,6,10,12, 15 and 30. The 60-year cycle of planet Jupiter moved through one zodiac sign in 361 days. The day had the following sub-divisions :

1 Day = 60 *Ghatika*
1 *Ghatika* = 60 *Vighatika* or *Pala*
1 *Pala* = 6 *Prana* {Also, 1 *Pala* = 60 *Vipala*}
1 *Prana* = 10 *Vipalas*
1 *Vipala* = 60 *Vipratipala*

Thus, 1 *vipratipala* was $1/12.9^6 \times$ 106 of a day's duration. The unit *Vipala* remained remarkably useful in the ancient Indian astronomy.

The Egyptians divided their day in 12 parts and likewise the night. They also claimed to be the originators of the sub-division of hour, *viz.*, 60 minutes to the hour and 60 seconds to the minute. It were probably the ancient Persians who visualised this division of the day. The doin was also divided into 6 watches of 4 hours (existing time) each. Thus, 1 Hour = 2½ *Ghatika*; 1 minute = 2½ *pala* and 1 second = 2½ *Vipala.*

It was in A.D. 996, when the escapement arrangement used in the present day watches was invented by Pope Slyvester II. The invention of double pendulum clock by Peter Light-foot of Glastonburg was accepted in A.D. 1340. The invention of pendulum clock was, however, attributed to Galileo in 16th century. The present basic time unit *second* is defined as 1/31556925, 9747th of the mean tropical year as at 12.00 hours on January 1, 1900. This duration has now been standardised to 9192631770 periods of caesium 133 atom at two hyperfine levels and accepted at 13th Generale Conference on Weights & Measures in 1964.

Metric unit of time

Although the duration has been perfected and standardised with enormous care, the need for adoption of metric time units has ever been increasing. As had already been visualised about acceptance of metrication of coinage, length and mass units, the system has given a positive boost to industry and economy. Time is now ripe for considering a changeover to metric units in time measurements. A metric second is defined as :

One metric second is the time interval between any two successive events that take place at intervals of the fraction $1/73 \times 10^6$ of mean tropical year (Ephemeris Time)—present duration 31556925.9747 seconds (existing). The metric second will correspond to 3973852058.7 periods of casesium-133 atom".

It will not be out of place to mention that the duration of "The metric second" also approximates the duration of *Vipala*, so accurately used by Indian astronomers.

BRIJ BHUSHAN VIJ

SCIENCE IN INDUSTRY

Building bricks from paddy husk

BURNT clay bricks constitute an essential building material and their price is rising steeply in many states. In Assam and West Bengal the price varies from Rs. 150 to Rs.190 per thousand, and is therefore becoming out of reach of the common man. The Regional Research Laboratory (RRL), Jorhat, has developed a suitable substitute brick based on paddy husk as raw material. The paddy husk-based bricks can be used for small constructions. A brick wall constructed out of these bricks at Jorhat has withstood three seasons so far.

The process for the production of paddy husk bricks is as follows. Paddy husk is pre-treated to remove unwanted elements and mixed with suitable quantities of filler, binder, other chemicals and water. The mix is fed into a hand-operated brick-making machine. The bricks are cured for a minimum period of 7 days and used for construction. These bricks can be made at any construction site. No firing is needed.

The paddy husk bricks are light in weight, cheaper than burnt clay bricks, result in reduced dead load, and are easy to handle and possess better insulation than conventional bricks. Also, seasonal changes do not come in the way of their production.

The bricks, which have been tested in accordance with IS: 1725-1960, have the following properties:

Compressive strength: 25 kg/cm^2 as against 18 kg/cm^2 for soil cement blocks.

Density: 1.50 g/cm^3 as against 2.0 g/cm^3 for clay bricks.

Weathering tests conform to the above IS specifications.

Moisture absorption in 24 hr is 12—14% as against allowable absorption of 15%.

By changing the chemicals used, bricks having a strength of 40 kg/cm^2 and comparable to burnt clay bricks can be manufactured.

The main raw materials required are: soil, paddy husk, cement and some chemicals; all these are available indigenously.

The main equipments required for making the bricks include mixer (electrically operated), brick-making machine and weighing machine.

The total capital outlay for a unit producing 10,000 bricks per day (3 shifts) would be Rs. 40,000 (Rs. 10,000 towards building, Rs. 10,000 towards equipment, and Rs. 20,000 as working capital for a month). The cost of production is estimated at Rs. 90-95 per 1000 bricks.

Rapid-setting lime plaster

LIME plasters have long been in use and have been severely tested by time. They are characterized by high plasticity, workability and water retention. They adhere well to the walls and are resistant to rain penetration. They tend to have good acoustical properties and show high fire ratings. However, they suffer from the drawback of being slow-setting, and this has acted as a deterrent to their use in speedy construction.

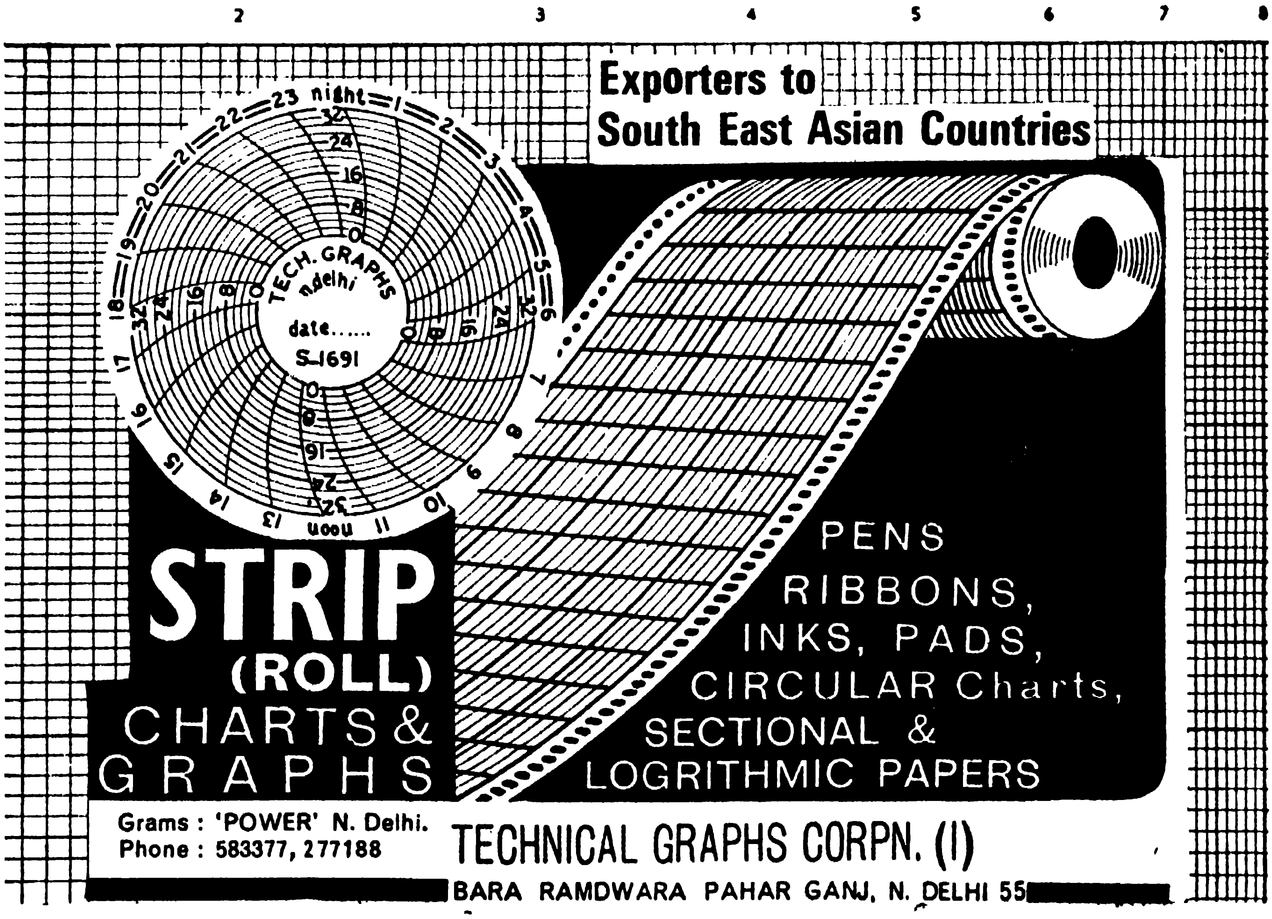
To overcome these difficulties, a rapid-setting lime plaster has been developed by the Central Building Research Institute (CBRI), Roorkee. This is endowed with all the desirable properties of lime, yet sets faster and develops good early strength.

The plaster starts setting in about 2 hr and becomes fairly hard in about 24 hr, thus providing sufficient working time and at the same time ensuring speed of construction. It develops adequate strength in 28 days. The plaster can be mixed with two to three parts of sand before application. It is applied as a single coat plaster but may be applied in two coats if better finish is desired. It can take smooth finish. The plaster is specially suited for plastering internal surfaces but may also be used externally as well in situations where the incidence of rainfall is not high. It adheres well with the background. Its application is easy and does not involve any special technique. It is economical. The plaster itself is white in colour and acquires the colour of the admixture. Judicious addition of suitable colouring materials can result in the production of numerous shades; otherwise the plaster gives white finish.

With the ever-increasing demand for plastering materials and perennial shortage of traditional building materials, the plaster appears to have good potentialities.

The plaster has been thoroughly tested in the laboratory. Besides, it has been tried in the field on certain buildings. Its performance has been found to be satisfactory.

The estimated capital investment for a plant to produce 5 tonnes per day is Rs. 1.10 lakh and the cost of production is about Rs. 175 per tonne.



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BOOK REVIEWS

TECHNOLOGY OF TEXTILE PROCESSING, VOL. I: TEXTILE FIBRES by Dr. V.A. Shenai, *Sevak Publications, Bombay*, 1971, Rs. 25/-.

IN his preface to the book, Dr. Shenai claims that his object in writing this book is to introduce the subject of textile fibres and try and explain in simple terms the different concepts which are essential to understand the chemistry of the fibres and the processes of production. The book has indeed achieved its objectives in that it is written with lucidity and covers all or almost all known natural and man-made fibres used for textile purposes, their properties and the manufacture.

The introductory chapter, "General Considerations" is written in an easy style, free from purely scientific or technical expressions and familiarises the reader in the language of laymen with the whole complex chemical structures of textile fibres. The few lines in which the molecular structure is explained is a very good example of how scientific ideas should be presented to laymen. A clear picture is given of the molecular content and characteristics, and the chemical properties of a few major textile fibres such as cotton, woollen, and syntheic fibres like nylon, terylene, are examined to arrive at basic and general molecular characteristics of textile fibres. Then other properties such as count, denier, spinning properties, strength and elasticity are explained. The narrative form of explanation and simple language make this chapter one from which a layman could well have a fair perception of basic scientific matters relating to textiles and textile fabrics. This is followed by a full examination of cellulose, its chemical analysis and its role in textile manufacture.

The other chapters are devoted to specialised study of individual textile fibres. Cotton, woollen, silk, rayon, polyamide, polyester, polyacrylonitrile, polyvinyl, chloride and alcohol, polyolefin and polyurethane fibres are examined at length. The reader is then told of recent developments in textile fibres. The identification of textile fibres and the tests and methods of doing so form the subject of the last chapter.

An interesting feature of the chapters on individual textile fibres is the historical introduction given by the author in each case. He tells us how cotton is referred to in the *Rig Veda*, which gives it a possible age of 3000 years. But the discovery of wool was perhaps earlier dating from the time man discarded animal skins in favour of garments made from woollen fibres. This would indeed be the date of the origin of the textile industry and not acurately assignable. China is credited with the discovery of silk and they were able to guard the secrets of sericulture for 3000 years, as the story goes, a Chinese princess who mastered the art was captured by the Japanese in B.C. 2600 or thereabout. In regard to man-made fabrics, the story element is provided by narration of the early attempts at discovery, as in the case of rayon of Robert Hooke, Reaumer, and others.

As the historical introduction is over, the author settles down to business and gives a full description of the growth, the agricultural methods of growing cotton and the general properties of cotton fibre with details of use of ginning machines. In the chapter on silks, there is a brief description of sericulture, reeling, throwing and manufacture which are independent parts of the silk industry, silk protein and varieties and chemical properties of silk. We are then told what rayons are and how they came to be discovered. The chemistry of the viscose process and the various steps in the manufacture of viscose rayon such as purification of cellulose, conditioning of the wood pulp, steeping, shedding and ageing process are clearly set out. These are augmented by two illustrations. Fig. 23 which details the various chemical steps involved in the manufacture of viscose rayon and Fig. 24 wich gives the flowsheet for the manufacture. All information for production thereof is given step by step. The same method of exposition with diagrams and flowsheets is adopted in the chapters on acetate and cuprammonium rayons.

We are then given an account of how synthetic fibres developed, the story of synthetic fibres as the author calls it. This gives us the theoretical background, chemical nature of polymerisation, followed by the scientific history of the development of nylon, terylene and the rest of the synthetic fibres. A whole chapter is developed on the detailed chemical analysis of the polyamide fibres and the processes involved in their manufacture. Similar treatment is given to all other man-made fibres listed earlier in this review.

The details given in the chapter on identification of textile fibres gives ready reference material on the industry. The tests given may perhaps be of use to forensic science in the detection of crime where there is a need to identify material which has been burnt or otherwise destroyed.

A feature of the volume is the profuse aids given in the form of illustrations, Tables, flowsheets, etc., which make the written matter doubly clear.

(*Continued on page 454*)

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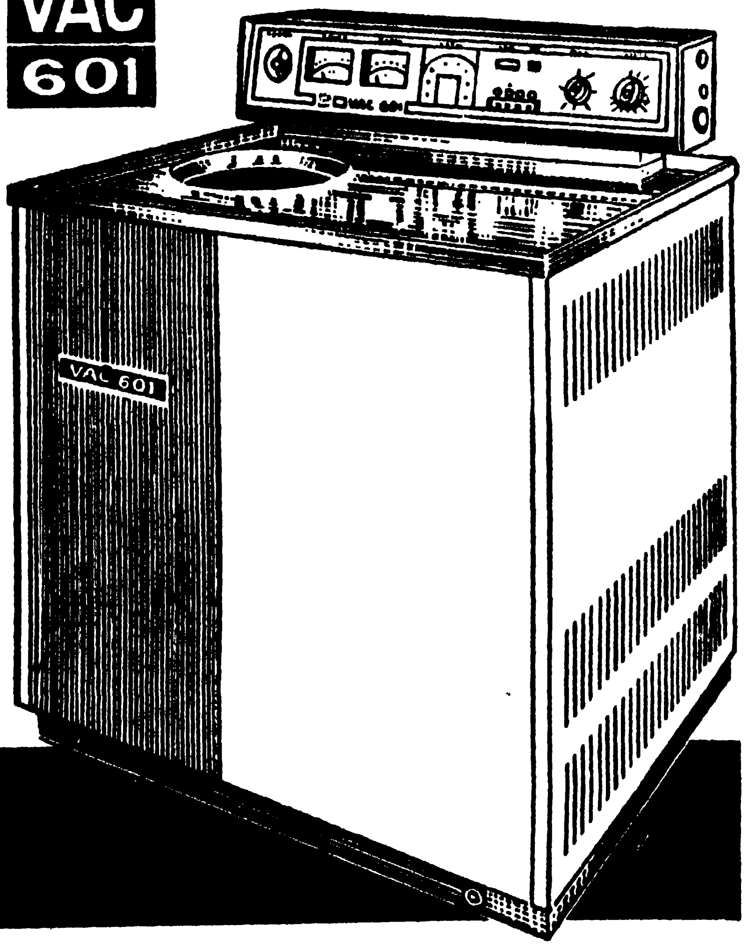

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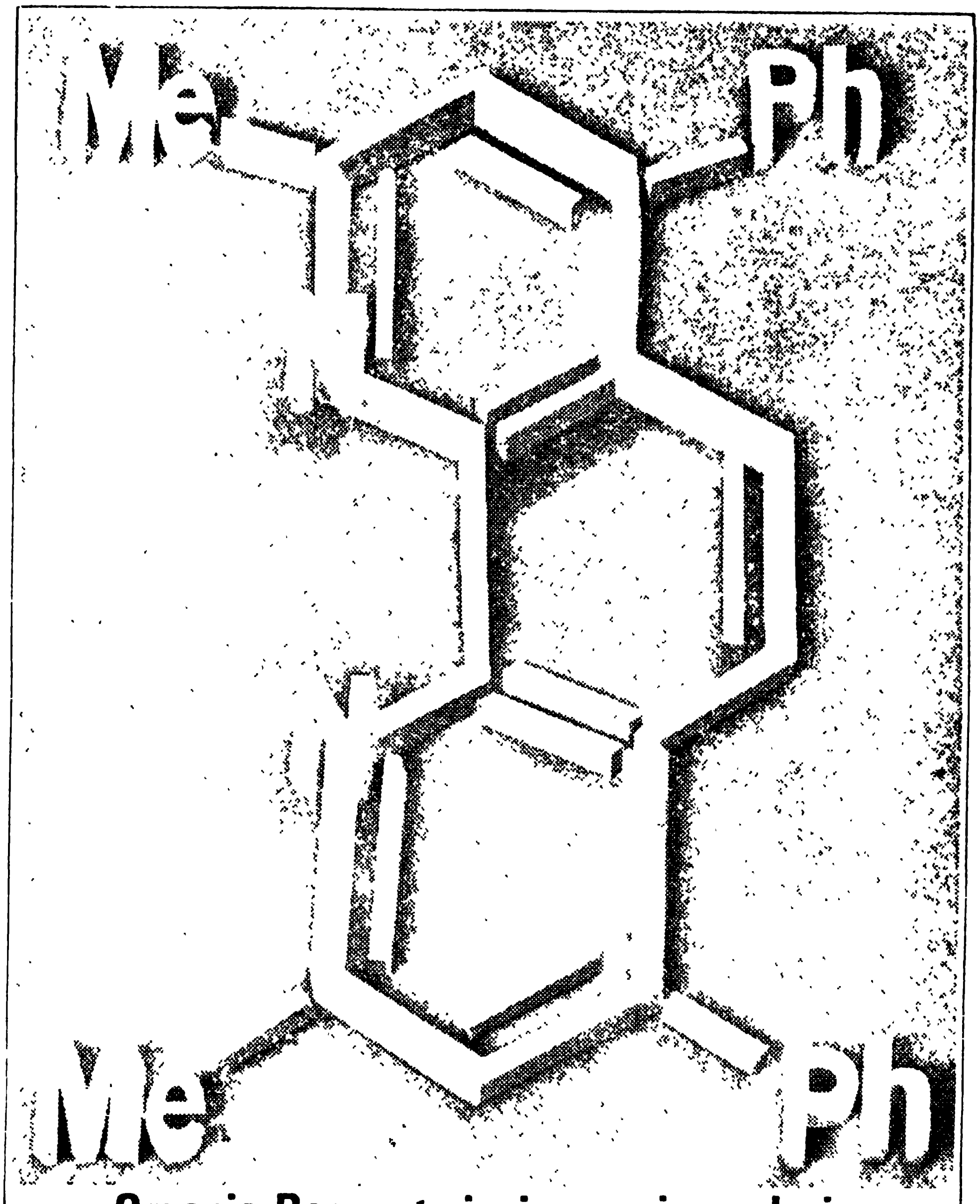

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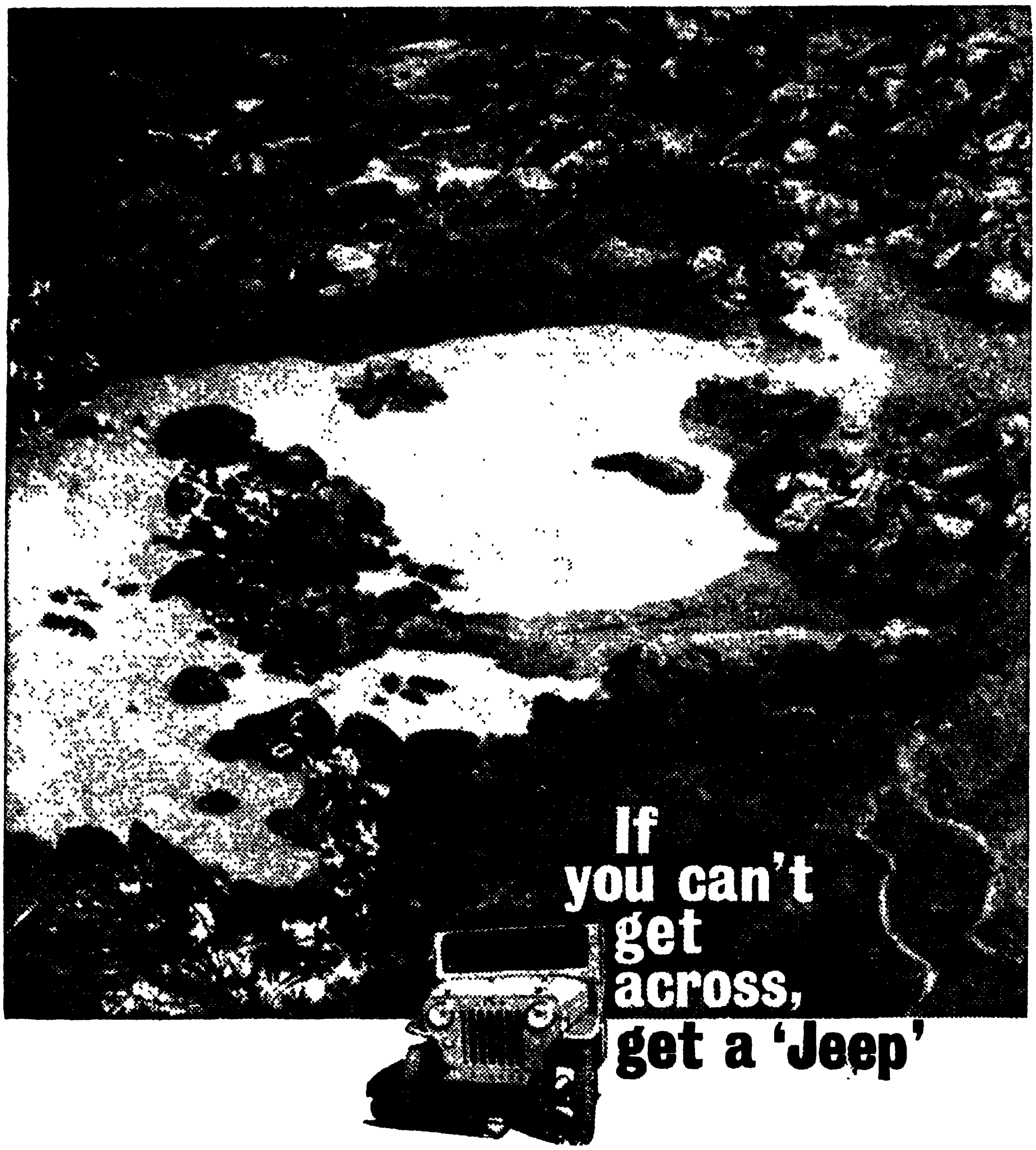

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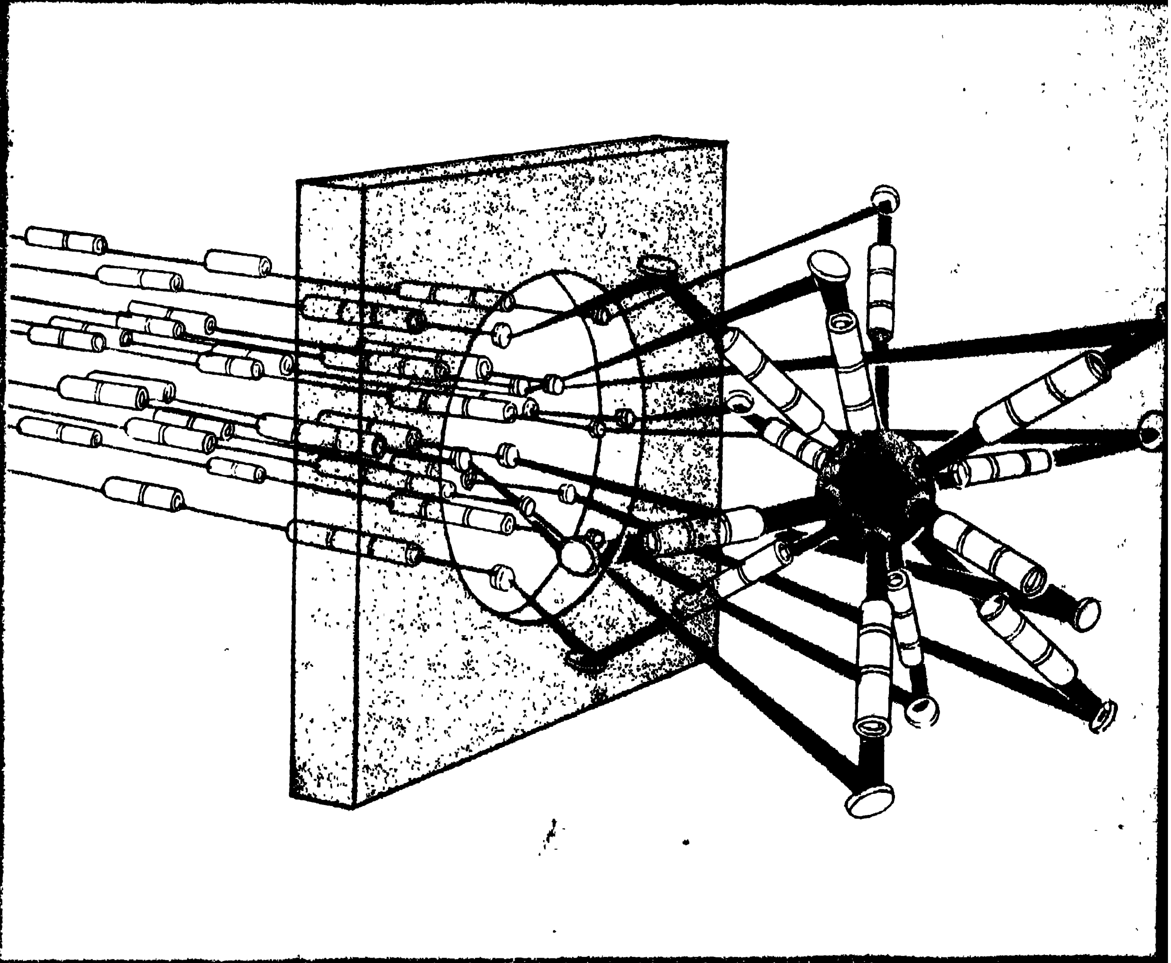

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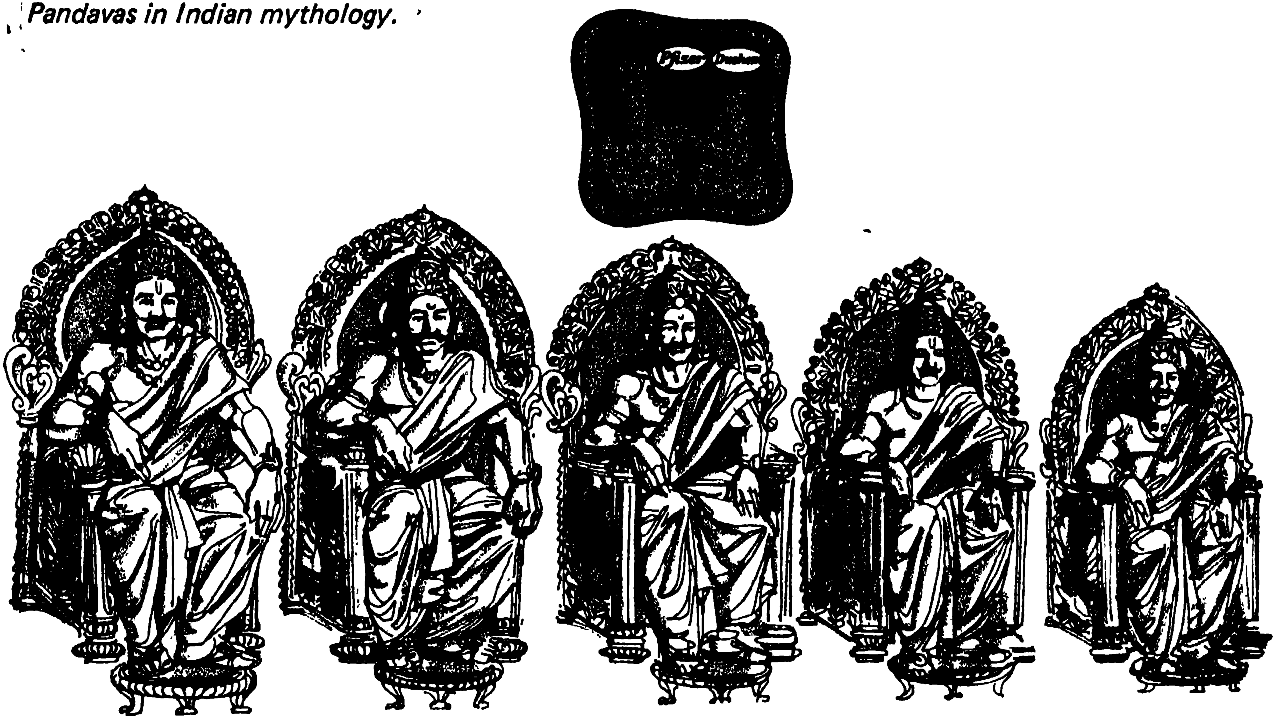

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Cover: **Multibeam Laser Facility scheduled for completion in 1977 at Lawrence Livermore Laboratory, U.S.A. The combined beams will be capable of irradiating test pellets with 10 Kilojouls of optical energy providing power output equivalent to 20 to 100 tetrawatts (*Courtesy*: *Scientific American*).**

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LETTERS

S.N. Bose

Sir, Ref: article on Satyendranath Bose (*S.R.* March, 1974). Louis Pasteur (1822-1895) of France once wrote:" Scientists have a country; science has none." And like Pasteur, the great majority of the 19th century scientists regarded themselves as "citizens of the world." Later, early in the current century, Dr. Pozzi said: "There is no conflict or hostility among scientists throughout the world....science is neither French, nor German nor British; it has now become universal."

Despite these writings, it is a matter of great surprise to learn that "Madame Curie (1867-1934) dismissed Bose by saying that he should learn French for six months and then go back to her"; and this rebuff to Bose when he had already studied French for 15 years! That a physicist of such brilliance with not less than 24 papers to his credit could not come to eminence even in the land of his birth because of lack of goodwill and cooperation from scientists of international fame is a matter of great regret though Keswani in all humility writes: "How much of this is to be attributed to a lack of aggressiveness or will or even ambition in his nature is difficult to assess." Perhaps, the fact is that Padma Vibhushan S.N. Bose remained throughout his life reconciled to the saying "I must do something" rather than to the view that "Something must be done."

D. Vaidyanathan
Head, Biology Dept.
S.I.E.S. College of Arts & Science
Bombay

Technical terms

Sir, The article by Visvapriya Mukherji on "The evolution of scientific and technical terms" (*S.R.* March, 1974) gave me interesting reading. As Germans have retained the Latin-based words in scientific terminology, in India Sanskrit-based scientific terminology can be used in all the Indian languages. I want to know the role of CSIR in the evolution of Indian scientific terminology. I hope *S.R.* will publish articles on this subject.

G.V. Mallan
Poona

Defective vasectomy

Sir, Within 48 hours of vasectomy, I developed complications in the form of swellings on various places and specially on the inguinal route and also suffered severe back pain. While surgeons are still arguing their opinions, I have been suffering for the last five months inspite of varied treatment.

I would like to bring my case to the notice of scientists and authorities so that further research be conducted to know the defects (if any) or to reconsider the desirability of mass scale application of this technique. Some other people are also complaining of various side effects.

Will it be possible for any of the experts in the field to give his opinion?

P.K. Rao
R.S. & P.O. Gondumri (Gondumri)
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Suggestions

Sir, I liked very much the article "All about aflatoxins" by K.R. Natarajan published in *S.R.* March, 1974. I request you to publish a full article on "The metallic bond—Pauling's theory" in some issue of *S.R.*

Narendar K. Sharma
Jammu

II

Sir, I request you to publish an article on "Hypothalamic control of pituitary gland" in one of your coming issues. The article should be based on recent research work.

Shiv Mohan Singh Mouria
Dept. of Zoology
B.H.U., Varanasi

III

Sir, I request you to publish a full article on "Gills in fishes." Has any scientist so far tried to make 'artificial gills'? If so, how far has he succeeded? Please give some information regarding the mechanism and cause of 'electric shock' by some marine fishes.

Avninder Singh Grewal
Lalton Kalan
Ludhiana

IV

Sir, I would like you to publish some articles on "Flame Photometry" and "Radio-tracer technique in analysis."

Basant Kumar
D.N. College, Meerut

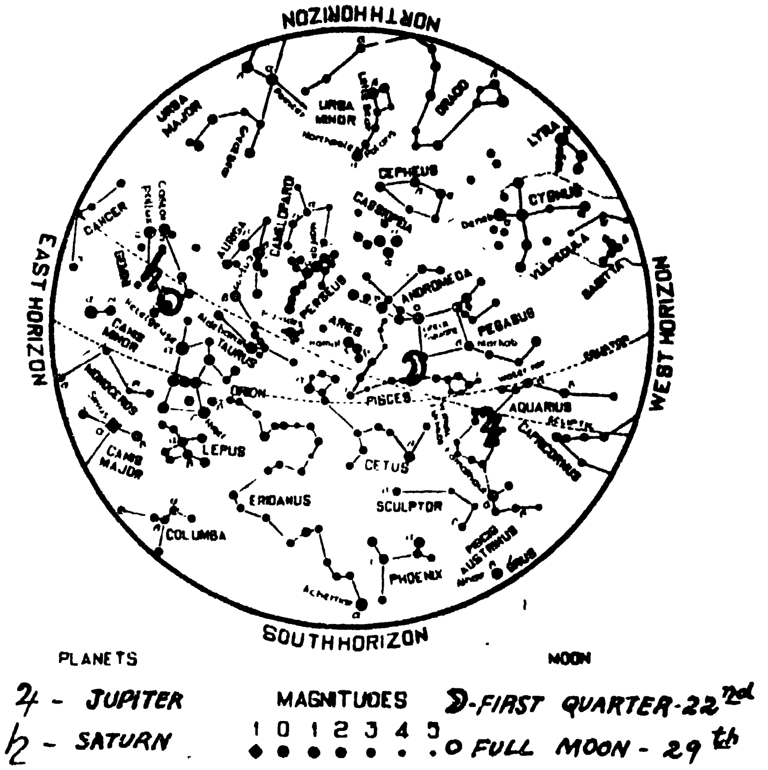
Instant colour photography

Sir, The article "Principles of Colour Photography" (S.R., Aug. 1974) by R. Ramaswamy gives us the best way of understanding the mechanism of colour photography. Besides, the principle involved in colour photography is also explained.

I want to say in this regard that there is another way of processing colour films known as "Instant colour process". The instant colour process operates by a wonderfully ingenious, subtractive colour, three layer scheme basically similar to the one shown in the article. However, an important difference is that here the colours are transferred from the emulsion to a white plastic sheet, actually making it a direct printing process. The subtractive dyes (yellow, magenta and cyan) are present as such in the instant colour emulsion as subtractive group on base-soluble photographic developers. The final print is a transparency against a white background. The process has the considerable advantage of having no colour-forming reactions during development.

Chiranjib Sil
Faculty of Science
Banaras Hindu University

PLANETS AND THEIR POSITIONS—DECEMBER 1974



The moon

New moon occurs on 13th at 9-55 p.m. and full moon on 29th at 9-21 a.m. I.S.T. The moon passes about three degrees south of Saturn in the evening of 2nd, about a degree south of Mars on 12th, seven degrees north of Jupiter in the evening of 20th and again about two and a half degrees south of Saturn in the night of 29th. The lunar crescent becomes first visible after the new moon day in the evening of 15th. The moon is at perigee or nearest to the earth on 3rd and at apogee or farthest from it on 19th.

The sun is at the winter solstice on the 22nd.

Solar eclipse

There will be a partial eclipse of the sun on the 13th but it will not be visible in India.

The planets

Mercury (Budha) is too near the sun to be visible during the month being in superior conjunction on 20th. It moves from Scorpio (*Vrischika*) to Sagittarius (*Dhanus*).

Venus (Sukra) is too near the sun to be visible during the first quarter of the month. Thereafter it reappears as an evening star and sets about an hour after sunset. It moves from Scorpio (*Vrischika*) to Sagittarius (*Dhanus*). Its visual magnitude is about —3·4.

Mars (Mangala), visible in the morning sky, rises about an hour before sunrise during the first half of the month and about one and a half hours before it during the second half. It passes about five degrees north of the star Antares (*Jyestha*) on 23rd. It moves from Libra (*Tula*) to Scorpio (*Vrischika*). Its visual magnitude is about —1·7.

Jupitar (Brihaspati) sets at about local midnight during the first half of the month being in quadrature with the sun on 2nd. Thereafter, it sets about an hour and a half before local midnight during the second half of the month. It is in Aquarius (*Kumbha*). Its visual magnitude is about —1·9.

Saturn (Sani) rises about two hours after sunset during the first half of the month and about an hour after it during the second half. It is in Gemini (*Mithuna*). Its visual magnitude is about —0·2.

(*Source:* Nautical Almanac Unit of the Meteorological Office, Alipore, Calcutta-27).

CONTROLLED POWER FROM FUSION REACTORS

OM PAL SINGH

The main object of controlled fusion research is to bring together the nuclei of fuel to such close distances that fusion can take place with a resultant release of energy

IT has long been realised that in not too distant future the present sources of energy will be considerably exhausted. At present, total energy consumption for all countries is about 1×10^{17} B.Th.U. per year. Since the world's population is steadily growing and the power use per capita is also increasing, the rate of energy utilization by the year 2000 could well be five to ten times the current value. According to one estimate, the known reserves of coal, oil and gas which are supplying the major portion of world's energy requirements, would be equivalent to roughly 4×10^{19} B.Th.U. This means that within 100 years the world's economically useful reserves of fossil fuels may be near exhaustion. Even when some allowance is made for errors in the foregoing estimates, the conclusion is inevitable that new sources of power must be found during the next 50 years if the earth is to support the growing population with some increase in living standard.

Since ancient times man has endeavoured to exploit environmental energy which includes sources such as solar energy, energy from tides, wind and water flow and the energy which results from thermal effects or thermal gradients in the earth and oceans.

Solar energy

The use of solar energy to heat water has been known since the very inception of present civilization. Some developments have also been made in using solar energy for domestic heating and running heat engines, but these methods have not been economical. Recently some specially designed heat collectors have been suggested to maximise high solar energy absorbability. Collected this way, the thermal energy may be used to generate steam for a turbine-driven electric power plant. The direct conversion of solar energy into electric power through photovoltaic cell is quite attractive but again it involves high cost.

Geothermal energy sources are of interest for the production of power because they are free from chemical pollution and radiation hazards. In certain parts of the world, natural steam occurs which can be piped to a steam power-generation plant. This is being done in several countries. However, these sources are geographically limited and the life of the steam wells is uncertain.

Fossil fuels

A major portion of the energy consumed in the world comes from the chemical energy of the fossil fuels. In addition to fossil fuels, any exothermic chemical system can, in principle, be utilized as an energy source. Although some of the light metals such as aluminium show greater heats of reaction than the hydrocarbon fuels, their use is limited only to special applications as it takes more energy to recover these metals from their ores than can be obtained when they are used as heat sources.

Mechanical sources such as springs and flywheels have also found their use in certain applications. Recently, advances in energy storage in flywheels have been reported which make them competitive with present day storage batteries.

Dr. Singh is Scientific Officer at Central Design Office, Reactor Research Centre, Kalapakkam, Tamil Nadu.

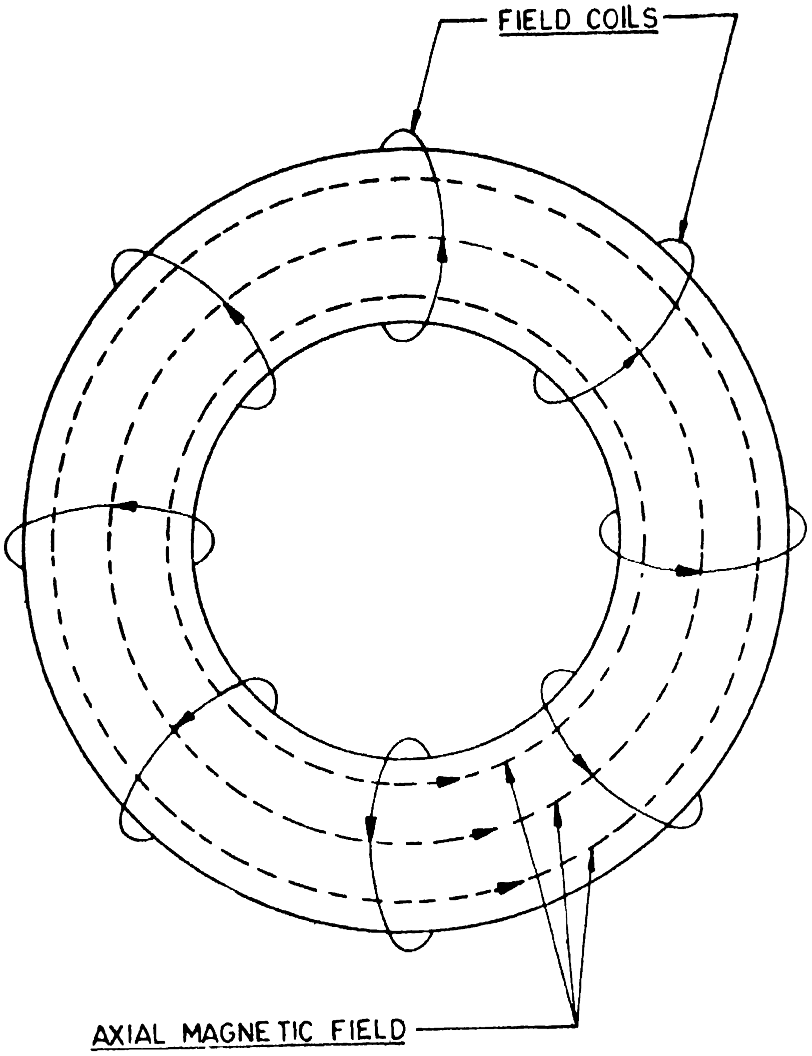


Fig. 1. Formation of an axial magnetic field in a closed, ring-shaped tube

Nuclear energy

Nuclear energy may be made available in two ways: (a) by fission of heavier elements such as ^{235}U and ^{239}Pu, and (b) by fusion of very light nuclei. The discovery of fission in 1939 revealed a new and highly concentrated source of energy. Some six years later, this energy was first utilised in the atomic bomb. Later, nuclear reactors were developed in which fission energy is converted into useful heat and then into electric power. But fission is not the complete solution to the energy problem. It is true that the world's resources of the basic nuclear fuels, namely, uranium and thorium minerals, are fairly abundant. Nevertheless, there are many countries that either do not possess these minerals or do not have the means for producing the best fuels from them. Another serious problem involved in fission power is the problem of safe disposal of radioactive wastes. In the coming years this problem, if not solved satisfactorily, may assume a form more formidable than the present day problems of air and water pollution resulting from fossil fuels.

It is such considerations that make nuclear fusion of exceptional interest as a possible source of power. Historically, the existence of this possible source of energy was known much earlier than the discovery of fission. Fusion of nuclei plays an important role in nature being the basic energy source of the sun and the stars.

The basic fuels for fusion are the heavy isotopes of hydrogen, namely, deuterium and tritium. Deuterium occurs in sea water in the ratio of about one part in 5,000 and can be recovered at a low cost. Because of the low cost and availability of deuterium, it would be preferable to utilise this isotope alone, the fusion process would then involve only deuterons. Two such reactions occurring roughly with equal probabilities are known:

$$^{2}_{1}D + ^{2}_{1}D \rightarrow ^{3}_{2}He + ^{1}_{0}n + 3.2\ \text{Mev}$$

$$^{2}_{1}D + ^{2}_{1}D \rightarrow ^{3}_{1}T + ^{1}_{1}p + 4.0\ \text{Mev}$$

where n represents a neutron and p represents a proton. The triton formed in the second equation can react fairly rapidly with another deuteron, as

$$^{2}_{1}D + ^{3}_{1}T \rightarrow ^{4}_{2}He + ^{1}_{0}n + 17.6\ \text{Mev}$$

Since the two deuteron—deuteron (or D-D) reactions take place at about the same extent, and one of them is immediately followed by the D–T reaction, the net energy release for the fusion of deuterons is $3.2+4.0+17.6 = 24.8$ Mev. From this result it can be calculated that complete fusion of deuterons in one gram of deuterium will yield 5.6×10^{10} calories. (The mass of a deuteron is 3.34×10^{-24} gm; five deuterons weighing 1.67×10^{-23} gm release $24.8 \times 3.8 \times 10^{-14}$ calories upon fusion). One litre of ordinary water contains about 0.003 gm of deuterium and so is equivalent to 1.5×10^{9} calories. This is approximately the combustion energy of 1,400 litres of gasoline. The total amount of deuterium in the ocean is estimated to be 4.5×10^{19} gm; its fusion energy content is thus 2.5×10^{30} calories or roughly 3×10^{20} kilowatt-years. At the world's current rate of power consumption of 5 × 10^9 kilowatts, the reserves should last billions of years! Further, tritium can be produced artificially by neutron irradiation of lithium:

$$^1_0n \quad + \quad ^6_3\text{Li} \quad \longrightarrow \quad ^3_1\text{T} \quad + \quad ^4_2\text{He}$$

The abundance of ^{6}Li in earth's crust is about 2 parts per million and the estimated total energy content is about 10^{12} kilowatt-years. These figures coupled with the fact that fusion results in negligible amounts of radioactivity provided great incentive for the development of fusion reactors. The cost of obtaining the deuterium fuel from water is also not high. At present, it costs about 10 Paise to extract all the deuterium from a litre of water. Thus fusion is the ideal source of energy—cheap, abundant and available to all. But, unfortunately, there are problems to be solved before fusion power can become a reality.

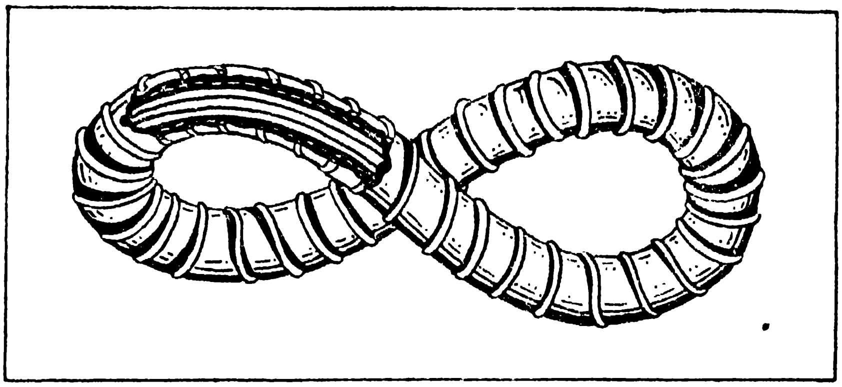


Fig. 2. Stellarator

Self-sustaining fusion

The main object of controlled fusion research is essentially to bring together the nuclei of fuel in pairs to such close distances that fusion can take place with a resultant release of energy. It, however, requires a great deal of energy to make a few nuclei fuse. A net gain of energy can result only if the reaction is made self-sustaining as it is in the interior of the sun. The attainment of self-sustaining fusion reaction in a controlled manner involves physical and technological problems which are even more complex than the technology of fission reactors.

One way of bringing two deuterons or one deuteron and one triton very close to each other is by accelerators such as cyclotrons. For example, if highly accelerated deuterons are allowed to strike a solid target containing deuterium, fusion of only a few nuclei occurs. Also only a very small proportion of the accelerated deuterons leads to fusion. Normally an impinging deuteron is deflected (or scattered) and at the same time is deprived of some of its energy. It then becomes essentially incapable of fusion with another deuteron. Much more energy is consequently spent in accelerating deuterons than is produced by the small number of fusion reactions that occur.

Another way of supplying energy to the nuclei is by raising the temperature. We know from the kinetic theory of gases that the kinetic energy of an atom (or nucleus) is proportional to the absolute temperature. Therefore, if we confine D–D or D–T mixture in some space and raise its temperature sufficiently, the nuclei will move randomly in all directions and repeated collisions will occur until fusion reactions take place. The energy liberated in this way will further heat up the gas and raise the temperature. Once the fusion is initiated, it will continue and the process could be made self-sustaining.

From the calculations based on experiments with accelerated deuterons, it is estimated that a temperature of the order of 10^8 K is required to cause fusion at an observable rate. At such a high temperature all the deuterium gas is ionised. This gas with positively charged nuclei and free electrons is commonly referred to as plasma, the fourth state of matter. Besides such a high temperature, it is also advantageous to raise the density of plasma so that the chances of fusion of nuclei in a given volume are better. Further, the plasma should be maintained in that state for a sufficiently long time to make the liberated energy more than the input energy. This is known as the 'break-even point' and depends upon the density of nuclei and the time. At a temperature of the order of 10^8 K, for a D-T reaction, the break-even point is reached when the product of time and plasma density is of the order of 5 × 10^{13} sec/cm.^{3}

Among the various problems encountered due to extremely high temperature required for nuclear fusion, one is of the confinement of plasma. The problem arises due to loss of energy by the nuclei as a result of contact with the walls. At a temperature of 100 million degrees the nuclei and electrons in the plasma, moving randomly in all directions, have an average speed of several thousand kilometers per second. Consequently, within less than a millionth of a second, all the particles will have hit the walls of the containing vessel and, as a result, they would lose essentially all their kinetic energy. In other words, the plasma gets rapidly cooled. An alternative must therefore be found to prevent the plasma particles from striking the walls of containing vessel.

Plasma confinement

The only method for plasma confinement that holds any promise at all is its confinement by magnetic field. The idea is based on the simple fact that a strong magnetic field will deflect charged particles from a straight path. However, if one attempts to confine a plasma by a magnetic field produced in a straight solenoid, the charged particles rapidly escape through the ends. To prevent this, one could build a very long solenoid but a more attractive alternative is to use an endless tube or a torus. A magnetic field is then produced inside the tube by passing a current through coils, wound around its outside (Fig. 1). But this arrangement fails to confine plasma because the magnetic field is stronger near the inner wall. It has been known, however, that if the magnetic field is distorted or twisted in such a way that the lines of force, after making a complete circuit, do not close upon themselves, the plasma drift is greatly reduced or even eliminated. This desirable result can be achieved simply by twisting a torus into a figure of 8. Such a device is known as a stellarator (Fig. 2).

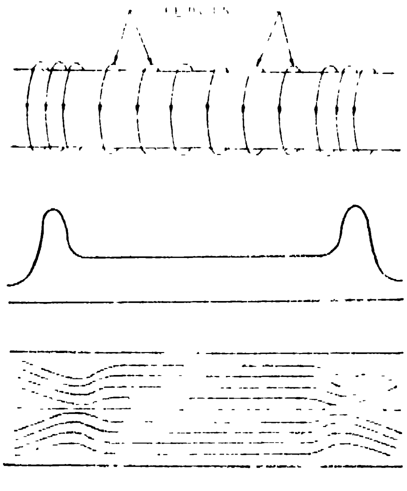


Fig. 3. Representation of a simple magnetic mirror system: (*Top*) shows the windings of the field coil, (*Middle*) shows how the strength of the magnetic field varies along tube, (*Below*) indicates the form of the lines of force

It is, of course, not only necessary to confine the plasma but also to create and heat it. One of the best methods of heating the gas at temperatures below about a million degrees is by ohmic heating, i.e., by passing an electric current through it. The plasma in a stellarator can be heated upto a million degrees by this method. At higher temperatures ohmic heating becomes rather slow and some other additional method of heating is required. One possible method is known as 'magnetic pumping.' The plasma in one or more regions of the stellarator tube is successively compressed and expanded by increasing and decreasing the magnetic field in these regions thereby heating it further.

Most of the work on stellarators has been done at Princeton University in the U.S.A. and the first experimental arrangement was put into operation in 1952. In these machines plasma is lost at a very high rate while the ohmic heating current is being passed. It has now been observed that it is not necessary to bend the tube in the figure of 8. The tube can be made in the form of a torus and the rotation of magnetic field lines can be produced by the use of helical windings outside the tube in addition to the coils producing the axial magnetic field.

Magnetic mirror confinement

An alternative approach to confine plasma may be to apply the magnetic field which is considerably stronger at the ends of the solenoid than in the centre. The regions of strong magnetic field behave like magnetic mirrors because they tend to slow down and, under certain conditions, turn back (or reflect) charged particles into the central region (Fig. 3). In this way the magnetic mirrors serve as stoppers that reduce the escape of particles from the ends of the tube. However, some particles moving directly along the axis of such a system always escape. Nevertheless, this method of plasma confinement shows considerable promise and is the basis of several methods such as 'adiabatic compression mirror method,' 'shock-heated mirror method' and 'high energy injection method' used for producing plasmas at thermonuclear temperatures.

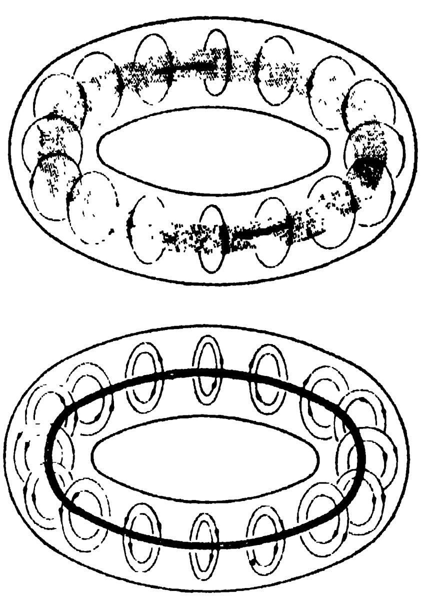


Fig. 4. Representation of the "Pinch effect" in a torroidal tube: (*Top*) beginning of the discharge, (*Below*) fully formed pinch

Pinch device

Unlike the stellarator and mirror machines, the confining magnetic field in the pinch devices is produced by currents flowing in the plasma itself and not in the external coils. If a small current or discharge is passed through a plasma, it heats the plasma which continues to fill the whole tube. However, if the current is large enough its interaction with the magnetic field it sets up causes the plasma to contract or pinch into a central region away from the walls of the discharge tube. Thus the passage of the current both heats and confines the plasma (Fig. 4).

The pinch device method of plasma confinement has in the past attracted attention. Experiments have been

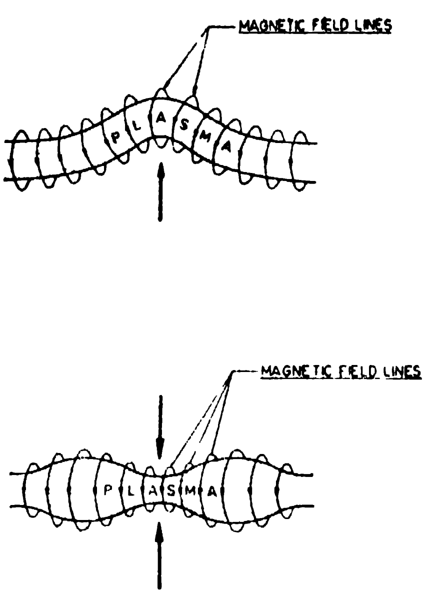


Fig. 5. (*Top*) **Kink instability in pinched plasma,** (*Below*) **sausage instability in plasma**

done in the U.S.S.R., the U.S.A., United Kingdom, France and several other countries, on both straight and toroidal pinch systems. Many toroidal pinch devices have been built, the better known vary in size from the *Perhapsatron* devices (bore 50 mm) in the U.S.A. through *Sceptre* (bore 300 mm) to *Zeta* (bore 1000 mm) in the United Kingdom, and *Alpha* in the U.S.S.R.

Early work on pinch devices showed that the pinched plasma was unstable because of the so called 'kink' and 'sausage' instabilities (Fig. 5). Any small kink in the pinched column grows rapidly because the magnetic pressure is stronger on the concave side of the kink than on the convex side. This is called the kink instability. The 'sausage' instability results when plasma tends to pinch or neck itself off at one or more points along the column and thus cuts itself into pieces. Stabilization of pinch might be achieved by putting a strong longitudinal magnetic field through a plasma.

All these devices suffer from a number of instabilities, the plasma changing from its simple form to some more complicated one, separating the charges and producing electric fields and drift motions across the magnetic field. Most of these instabilities are well understood and methods such as shear stabilization (in the case of toroidal systems), construction of magnetic wall and the use of Joffe bars (in the case of magnetic mirrors) have been used to eliminate some of them. However, there are some instabilities which result from a build up of waves, pulsations or other small disturbances in the plasma. If these disturbances become sufficiently violent they can cause complete breakdown.

If the difficulties of the confinement of plasma are solved completely, the first fusion reactor probably will be as shown in Fig. 6. The reacting plasma is a 50-50 mixture of fully ionised deuterium and tritium gases at a temperature of about 10^8 K. The fusion reaction in the plasma is

$$D+T={}^4He+n+17{\cdot}6 \text{ Mev}$$

Eighty per cent of this energy is released as a flux of 14.1 Mev neutrons which are moderated in the lithium blanket. The resulting thermal energy is then transferred via liquid lithium (or other coolant) to heat exchangers as in fast breeder reactors. Tritium fuel is bred in the lithium blanket by neutron irradiation. The D-T plasma is most likely to be in toroidal configuration as in *Tokamak* (Russian machine based on 'pinch devices' of plasma confinement) or stellarator, though mirror machines are also not entirely ruled out.

The most significant development in fusion research has been the demonstration during 1969 of the first prolonged controlled fusion reaction in Russian *Tokamak T-3* facility. Two of the next generation controlled fusion reactor facilities now under construction, *Scyllac* (U.S.) and *Tokamak T-10*, have been designed to come to within 10^{-2} and 10^{-1} of break-even conditions respectively. The expectation of closing this remaining gap seems to be shared by most fusion plasma experts throughout the world.

Laser devices

Recent developments in the laser research have opened up new hopes of making fusion reactor a reality. Laser-heated fusion devices are found to be of great promise in solving the problem of plasma containment (*See* cover illustration). Laser radiation when focussed on a small pellet of solid deuterium-tritium

(*Continued on page* 475)

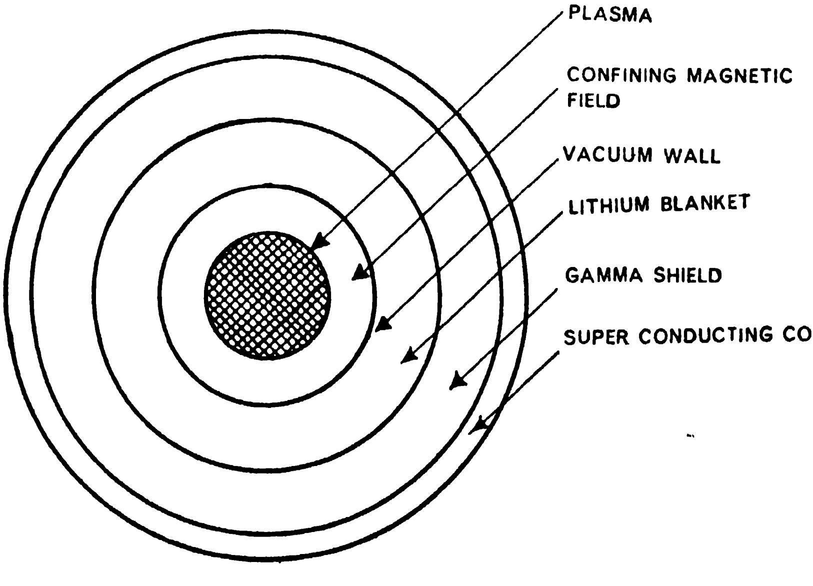


Fig. 6. A schematic cross-section of a conceptual D-T reactor

A CENTURY OF ASYMMETRIC CARBON

(1874-1974)

S.V. ESWARAN

Hundred years ago two young chemists, Jacobus Hendricus Van't Hoff and J.A. Le Bel, systematically put forth the idea of tetrahedral structure of carbon and its relation to the phenomenon of optical activity

EXACTLY hundred years ago in 1874, a 12-page pamphlet was written with diagrams drawn on one side and entitled "An attempt to extend to space the present structural chemical formulae with an observation on the relation between optical activity and the chemical constitution of organic compounds". The paper, originally written in Dutch, was the work of a young, twenty-two year old chemist and did not exactly set the Thames on fire. It would have passed almost unnoticed into oblivion had it not caught the scornful attention of the great German chemist H. Kolbe (1818-84). (He followed the tradition set by another great German organic chemist Justus von Liebig, one of the giants of the subject, in sofar as his editorial duties were concerned). Kolbe was the Editor of *Journal fur Prakatische chemie* from 1870 onwards and, like his mentor, used to launch scathing attacks on scientists and their works in his journal whenever he felt that they were wrong. The ageing Kolbe who was well past his best days in the subject chose to comment—a comment which has since become historic on the young man's paper—as follows:

"Will anyone to whom my worries may seem exaggerated please read, if he can, a recent memoir by a Herr Van't Hoff on the Arrangement of Atoms in Space, a document crammed to the hilt with the outpourings of a childish fantasy. This Dr. J.H. Van't Hoff, employed by the Veterinary College at Utrecht, has, so it seems, no taste for accurate chemical research. He finds it more convenient to mount his pegasus, the Greek legendary winged horse (evidently taken from the stables of the veterinary college) and to announce how on his daring flight to the chemical mount Parnassus he saw the atoms arranged in space."

He continued: "It is not possible to criticise this work even half way thoroughly because the play of fantasy in it dispenses completely and entirely with factual basis and is absolutely unintelligible to the sober chemist."

As if it was not enough, he added, "It is a sign of the times that the modern chemists feel themselves qualified and able to give an explanation for everything and when the results of experiments are not sufficient they seize upon supernatural explanations".

The young author of this text Jacobus Hendricus Van't Hoff had got, in the first instance, his paper translated into French but with little success. On the advice of J. Wislicenus (1835-1902), well-known for his preparation of the two isomeric forms of lactic acid, and who very kindly wrote a foreword, the paper was then translated and published in German (again at the author's own cost!). It was then that Kolbe saw it. Actually Kolbe had a dig even at Wislicenus for writing this foreword saying:

"Herewith Wislicenus makes it clear that he has gone over from the camp of the true investigators to that of the speculative philosophers of ominous memory, who are separated only by a thin medium from spiritualism".

This blistering attack by Kolbe actually turned out to be a blessing in disguise as it brought this small paper into the direct focus and soon the paper was being discussed hotly

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Dr. Eswaran teaches chemistry at St. Stephen's College, Delhi

Jacobus Hendricus Van't Hoff (1852-1911)

all over Europe. The paper presented for the first time the idea that the four valencies of carbon atom are directed in space to the four corners of a tetrahedron (Fig. 1). (A tetrahedron is a four-faced, solid figure with four equilateral triangles). Today, we know that this concept forms the very corner-stone of the vast subject of organic chemistry and really has far reaching implications.

Quite interestingly, in the same year another young chemist J.A. Le Bel (who was about twenty-seven years old then) also reached the same conclusions independently. He published his results in the *Bulletin of the French Chemical Society* in November 1874, about two months after Van't Hoff published his paper. Since Le Bel's paper was in French, it reached the scientific circles in other centres earlier than Van't Hoff's paper. Only in 1873, the two young men had been together in Wurtz's laboratory in Bonn but, as both have stated, they never discussed these ideas with each other and obviously kept them a secret. There was, however, no fight over priority in this case as both of them clearly reached almost identical conclusions independently.

In fact, there are slight differences in the presentation of the idea by the two scientists. Van't Hoff proposed a specific tetrahedral arrangement after he had considered the possibility of the four valencies of carbon being arranged in a planar fashion. The number of isomers to be expected on the basis of the planar model was found to be greater than the number found in the laboratory. For example, as shown in Fig. 2, two isomers would be expected to be found in the case of dichloromethane (CH_2Cl_2) if the four valencies of carbon were arranged in one plane. (This will be clear if we look at the figures carefully). In Fig. 2(a) the two chlorine atoms would be closer to each other in space than the two chlorine atoms in Fig. 2 (b). The two structures represented by Fig. 2 (a) and (b) will thus be different.

If, on the other hand, the four valencies of carbon were arranged in space in a tetrahedral manner around the central carbon atom, all the four positions would be equivalent. Thus no matter where the two chlorine atoms of dichloromethane are placed, no second isomer would be expected on the basis of this model. Since one and only one form of dichloromethane was known experimentally, it was obvious that the atoms around central carbon atom could not be lying on one plane.

Le Bel arrived at the same conclusions in a slightly different way.

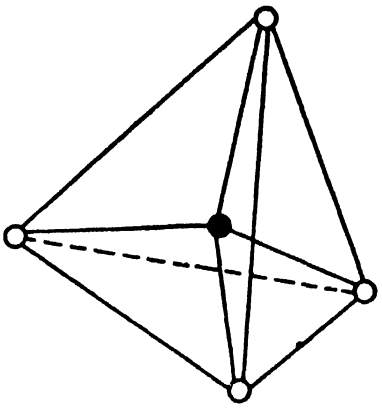


Fig. 1. A tetrahedron with the carbon atom at the centre. The four valencies of carbon are directed towards the four corners of the tetrahedron

He took it up as a more general problem and discussed the manner in which four different groups will join a tetravalent carbon atom as "a pure question of equilibrium". Unlike Van't Hoff, he mentioned the tetrahedron in his paper only once.

In 1930, W.J. Pope wrote "It is not yet settled whether Van't Hoff's view, that the carbon atom carries four valency directions directed towards the 4-apices of a regular circumscribed tetrahedron, is preferable to that of Le Bel, but the tendency of modern organic chemistry is certainly towards the Le Bel implication that the four carbon valencies are not so fixed."

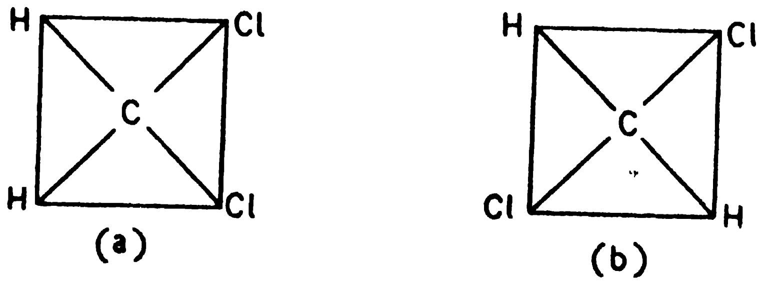


Fig. 2. The two isomers of dichloromethane expected on the basis of a planar arrangement of the carbon valencies proved wrong subsequently

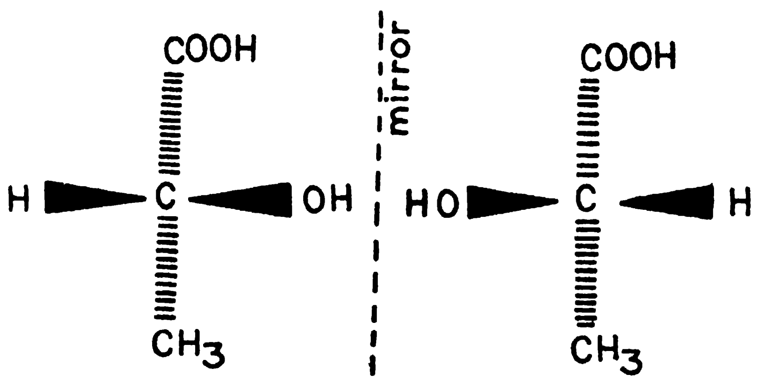


Fig. 3. Two isomers of lactic acid which are mirror images of one another. The central carbon atom is 'asymmetric.' Groups joined to it by dotted lines are below the plane of the paper while thick lines represent bonds above the plane of the paper

However, in 1951 confirmatory evidence as to the correctness of Van't Hoff's view was provided by the most ingenious experiments conducted with X-rays by J.M. Bijovet.

Optical isomerism

It was, however, realised by both Van't Hoff and Le Bel that on the basis of their tetrahedral arrangement of carbon valencies, if four different groups were attached to the carbon atom, there arises the possibility of the existence of two isomers which would bear a mirror image relationship to each other (Fig. 3).

A carbon atom to which are attached four different groups was called an asymmetric carbon atom. Soon its relation with optical isomerism was established and Van't Hoff in *Die Lagerung der Atome in Raume* wrote that an organic compound will show optical isomerism if it contains an asymmetric carbon atom (Fig. 4). Van't Hoff prepared about thirty different compounds containing asymmetric carbon atoms and all of these, as expected, exhibited optical isomerism. (A few 'exceptions' were, however, shown later to conform to the rule and their initial difference in behaviour was traced to impurities which could be removed with difficulty). These results also explained the isomerism exhibited by the lactic acids studied by Wislicenus.

While trying to find out what led these two young men to speculate as they did and whether they were the very first people to conceive of these ideas, we have to look back some twenty-five years before their time. One comes across the classic researches of Louis Pasteur on the tartaric acid conducted in 1848. He carried out the first successful resolution (i.e., separation) of a 'racemic compound' into the two optically-active isomers. Pasteur embarked on this project with a hunch that there was a relation between crystal shape and optical activity. He had, as L.J & M. Fieser's put it, the 'audacity' to think that some of the great chemists who had carried out studies earlier might have overlooked this point. Pasteur remarked in 1860 that the optical activity shown by the organic compounds, which persisted even in the dissolved state, appeared to indicate that the molecules themselves were not symmetric. He perceived that 'molecular disymmetry' alone is responsible for optical activity. This lack of symmetry is impossible in figures confined to two dimensions. He therefore reasoned that molecules must be 3-dimensional figures with atoms linked in a definite arrangement. He even spoke of a tetrahedral arrangement of the carbon valencies.

August Kekule, known as the "first chemical architect", was the person endowed with a deep and penetrating insight into molecular structure. Kekule switched on to chemistry from his own field of architecture after hearing the enthusiastic lectures of Liebig. He too, like Pasteur, was conscious of the need of 3-dimensional representation of the valencies of carbon. As early as 1867, he said that the inadequacies of molecular structure representation could be removed by using the tetrahedral model for carbon. It is again significant that Van't Hoff spent a year (1872-73) in Kekule's laboratory though he had found him rather unsympathetic.

Mention must also be made of August Laurent and C.J. Gerhardt—the two chemists who pioneered the structural theory of organic chemistry. Incidentally, it was Laurent who encouraged Pasteur in his work in 1848. As early as 1869, Paterno used the tetrahedron concept while representing the supposedly three isomers of dichloroethane. His

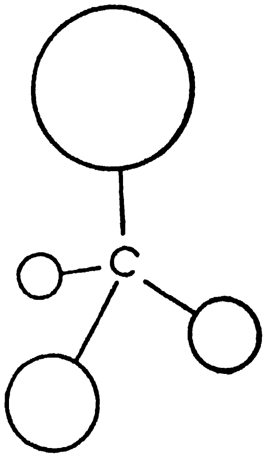
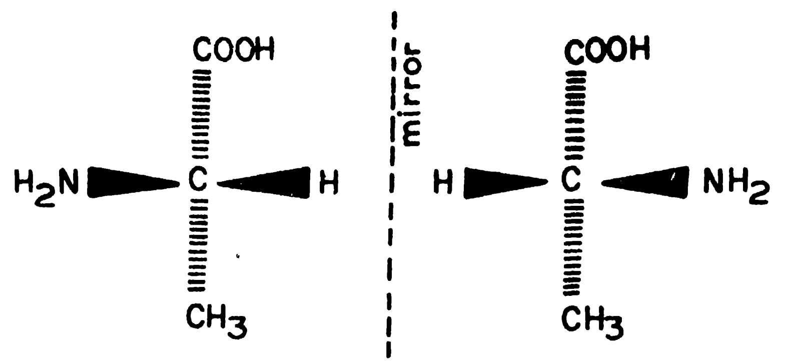


Fig. 4. An asymmetric carbon atom



L-Amino acid

D-Amino acid

Fig. 5. Mirror images of L and D amino acids

claims, however, were largely lost when it was known that so many isomers were not possible for this compound. In 1873 Wislicenus stated that the optical isomers of lactic acid obtained by him probably differed only in the arrangement of the same groups in space.

Now having known that the concept of the tetrahedral carbon atom had already been considered by Kekule, Paterno and others, and that the idea of the asymmetric structure of molecules capable of showing optical activity had been suggested by Pasteur, many questions may crop up in the readers' mind: What was revolutionary in the ideas presented by Van't Hoff and Le Bel? Is it not merely a logical outcome of Pasteur's work? If they were not the first people to put forth these ideas, what is their claim to greatness for? While it may be true they were not the very first to visualise these, it must be said to the credit of the two that apart from specifically talking of the tetrahedral arrangement they also systematically brought out the important implications of these concepts which had largely escaped the attention of the earlier workers. They also provided the missing link between the phenomenon of optical activity exhibited by many organic compounds and molecular structures.

No doubt earlier workers had hinted at the tetrahedral arrangement of the carbon valencies, the idea of molecular asymmetry too had been presented. But as J. Walker has said: "Separated these ideas remained unproductive; correlated they became endowed with marvellous fertility. Van't Hoff and Le Bel's great contribution to stereochemistry was to define the conditions under which the asymmetric structure appeared, namely, when the carbon atom was attached to four different groups. ...Not only did they state the bare principle, however, they showed it was a living one, drew deductions from it, applied it on all sides, and delivered it in short as an effective instrument into the hands of their fellow workers in chemistry. Otherwise, like Avogadro's principle it might have been forgotten and for years, perhaps, awaited some Cannizzaro to rediscover or revivify it".

Van't Hoff himself has said that while "Le Bel's starting point was the researches of Pasteur" his own studies originated from those of Kekule. He confessed that "Practically our ideas, so far as they concern the asymmetric carbon, amount to the same thing—explanation of the two isomerides by means of the tetrahedron and its image and disappearance of this isomerism when the two groups become idential by assuming symmetry and identity of the two tetrahedra".

Van't Hoff was one of those scientists who "rang" the bell quite a few times in their life time and was the recipient of the first Nobel Prize in chemistry in 1901. He was awarded the prize for "the discovery of the laws of chemical dynamics and osmotic pressure". In simple words, he discovered that solutions follow a law similar to the ideal gas equation $PV=RT$. Old chemists again found it difficult to follow that sugar dissolved in water behaved as a gas.

It is said that as a young man when Van't Hoff heard the sarcastic comments of Kolbe he at once went to the stables of the veterinary college, photographed the sorriest looking horse there, put it in his laboratory and labelled: 'Pegasus'. Herein he followed the example of his hero Byron and could afford to laugh at Kolbe, and say: "I awoke one morning to find myself famous". Van't Hoff died in 1911 at the age of fifty-nine.

The Frenchman Le Bel, on the other hand, lived up to the ripe old age of 83. He died in 1930. Le Bel was a quiet, retiring person and did not publish a great deal of experimental work. This could possibly be attributed to the fact that he did not hold an academic post and so found few collaborators. He wrote, however, on a wide range of subjects with a philosophical bent. He served as the director of petroleum works at Pechelbronn and believed very strongly in Mandeleev's theory that petroleum deposits originate from the action of steam on metallic carbides. He reported in 1891 the preparation of optically active nitrogen compounds—a result that could not be confirmed by other workers and was obviously wrong. He served as President of the French Chemical Society in 1892 and in 1893 alongwith Van't Hoff received the Davy Medal of the Royal Society. He is said to have retained his interest in science till the very end of his life. In April 1930, a few months before his death, he offered prize money to any one who discovered a green alga which fixed atmospheric nitrogen as ammonia (He had discovered it earlier but was unable to repeat his work). The work on asymmetric carbon atom which won him a place in the annals of science was in keeping with the remarkable achievements of the French in the field of optical activity.

Thus the studies of the pioneers like Pasteur, Kekule, Van't Hoff and Le Bel gave to the drab two-dimensional chemistry of those days a new third dimension in more than one sense. It has been rightly said that they "sowed the seed in a field from which has since grown the vigorous plant of stereochemistry".

How penetrating and precise insights into molecular structure these giants of chemistry possessed is quite evident from the fact that it took another 75 years to even confirm the ideas of Van't Hoff. This too was possible only due to the ingenious use of a sophisticated physical technique (X-rays). The significance of their contribution can be correctly gauged only when we look at the contemporary scene. Van't Hoff belonged to a generation who were taught at school that water has a formula HO! (The H_2O days were still to come).

Stereochemistry (i.e., chemistry that takes into consideration the arrangement in space of atoms in a molecule) is an all pervading subject today. The work of Van't Hoff and Le Bel has inspired many subsequent spectacular studies. Among these is the Nobel Prize winning work of Alfred Werner on complex compounds. The work of Profs. D.H.R. Barton and Odd Hassel now provides a more complete understanding of the 3-dimensional structure of molecules. Incidentally, they too received the coveted Nobel award jointly for their work. The study of reaction mechanisms which is forging ahead rapidly is also remarkably intertwined with the dynamic aspects of stereochemistry.

The subject of stereochemistry has gained strategic importance in the study of biological processes as well. This is so because enzymes, the biological catalysts, are known to show a high degree of 'stereospecificity' and react with one particular isomer alone. For example, only L-amino acids (which have the amino group on the left hand side, *see* Fig. 5) and not their mirror image isomers are assimilated by the body to synthesise proteins.

A proper understanding of the specificity shown in enzyme-controlled biological processes is possible only on the basis of a knowledge of the exact 3-dimensional structures of both the enzymes and the substrates with which they interact. In fact, life on earth is based solely on L-amino acids and if man were to find himself one day on a planet where life is based on the D-amino acids, he would starve to death in the midst of apparent plenty!

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CONTROLLED POWER *(Continued from page 470)*

fuel can produce very high density plasmas ranging from 10^{19} to 5×10^{22} per c.c. within 10^{-10} sec. Since the plasma created initially by the laser beams has a density very close to the solid state density (5×10^{22} atoms/cm^3), fusion reactions may be sustained in this case without any external confinement mechanism. Several laboratories in the world have successfully ignited fusion reactions in solid D-T fuel. However, the most important problem that still remains to be solved in making a laser fusion reactor practical and economical is that the total energy output in this case is less than the energy input.

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SUPPRESSOR MUTATIONS AND *t*-RNA

P.K. GUPTA

Suppressor mutations carried out by *t*-RNAs reverse the effect of a harmful genetic change in the sequence of a gene and restore the original sequence

MUTATIONS may take place due to a variety of changes in the DNA (deoxyribonucleic acid) molecule, the hereditary material. Different kinds of changes which have been studied in detail include: (a) replacement of single base (nucleotide), and (b) deletion or addition of a single base. The former include nonsense and mis-sense mutations and the latter, frame-shift mutations. A classification of these mutations is presented in Fig. 1.

Numerous examples are now available where the effect of any of these harmful mutations could be reversed by a subsequent change in the genetic material (DNA). If the subsequent genetic change is brought about at the place of the original change, this will be a simple case of reverse or back mutation where the original base sequence is restored. However, imagine that an original mutation has taken place, say, at A and a second genetic change which has reversed the effect of the former has taken place at another site B. Such a change will be called suppressor mutation. Suppressor mutations are now known for all the different kinds of mutations as shown in Fig. 1.

Suppressor mutations and suppressor *t*-RNAs

In most of the cases of suppressor mutations, altered kinds of *t*-RNAs (transfer ribonucleic acids) are involved in the suppression mechanism. Transfer RNAs, as we know, are adaptor molecules which take part in protein synthesis and each of them has a double specificity. A particular *t*-RNA will be able to recognize a specific amino acid and would also recognize a codon meant for this amino acid. Altered *t*-RNAs, taking part in suppression mechanism, are known as suppressor *t*-RNAs. In these suppressor *t*-RNAs, the original specificity with respect to a particular codon is altered, but the specificity for a particular amino acid remains unaffected. Different kinds of mutations and the associated suppressor *t*-RNA molecules are discussed.

Nonsense mutations and suppressor t-RNAs. Of the 64 available codons in the genetic code, there are three codons each of which is responsible for the termination of the polypeptide chain. These codons, also called nonsense codons, are UAG (amber codon), UAA (ochre codon) and UGA codon. Whenever a sensible codon mutates to give rise to one of these three termination codons, the change is called nonsense mutation (Fig. 2).

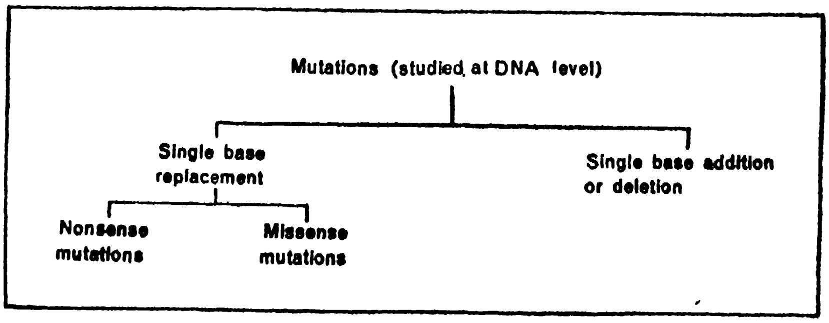
Mutations (studied at DNA level)
Single base replacement
Single base addition or deletion
Nonsense mutations
Missense mutations

Fig. 1. Classification of mutations

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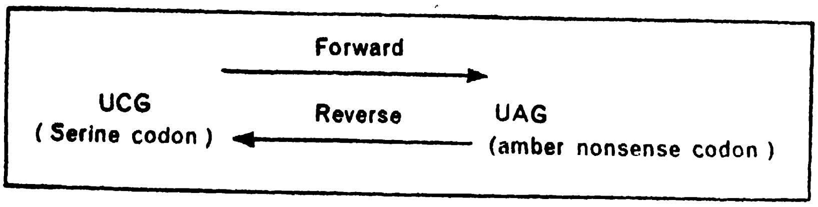

Fig. 2. A reversible nonsense amber

In the year 1965 and afterwards Dr. S. Brenner and his colleagues at the Medical Research Council Laboratory, Cambridge, England published a number of reports on the effects of nonsense mutations, particularly of the amber mutations that could be suppressed due to mutations at other positions. These mutations were called nonsense suppressor mutations. It was also discovered that in these suppressor mutations either the original amino acid or some other amino acid could be substituted. Different amino acids due to different suppressor mutations could be substituted at the position of nonsense mutation. For instance, in *Escherichia coli,* in a suppressor mutation Su_1^+, serine was substituted, in Su_2^+ glutamine was substituted and in Su_3^+ tyrosine was substituted. How is this substitution of amino acids brought about, and why are different amino acids in different suppressor mutations involved? Answer to these questions was given by the subsequent researches which showed that the suppressor mutations usually involve the presense of altered forms of *t*-RNA. These altered *t*-RNAs were called the suppressor *t*-RNAs.

James D. Watson of Harvard University, U.S.A. has briefly discussed the subject of suppressor mutations in the second edition of his book *Molecular Biology of the Gene*. According to him, the *t*-RNA-mediated suppression was first demonstrated with a nonsense mutation which blocked the synthesis of the coat protein of the RNA-phage R17. Suppressor *t*-RNAs are now known for each of the three termination codons (UAG, UAA and UGA). When structure of some of these *t*-RNAs was studied, it was found that the only alteration was in the anticodon region which enables the *t*-RNA to recognize a particular nonsense codon. The structure of an *Escherichia coli* suppressor, tyrosine *t*-RNA, is given in Fig. 3 and the

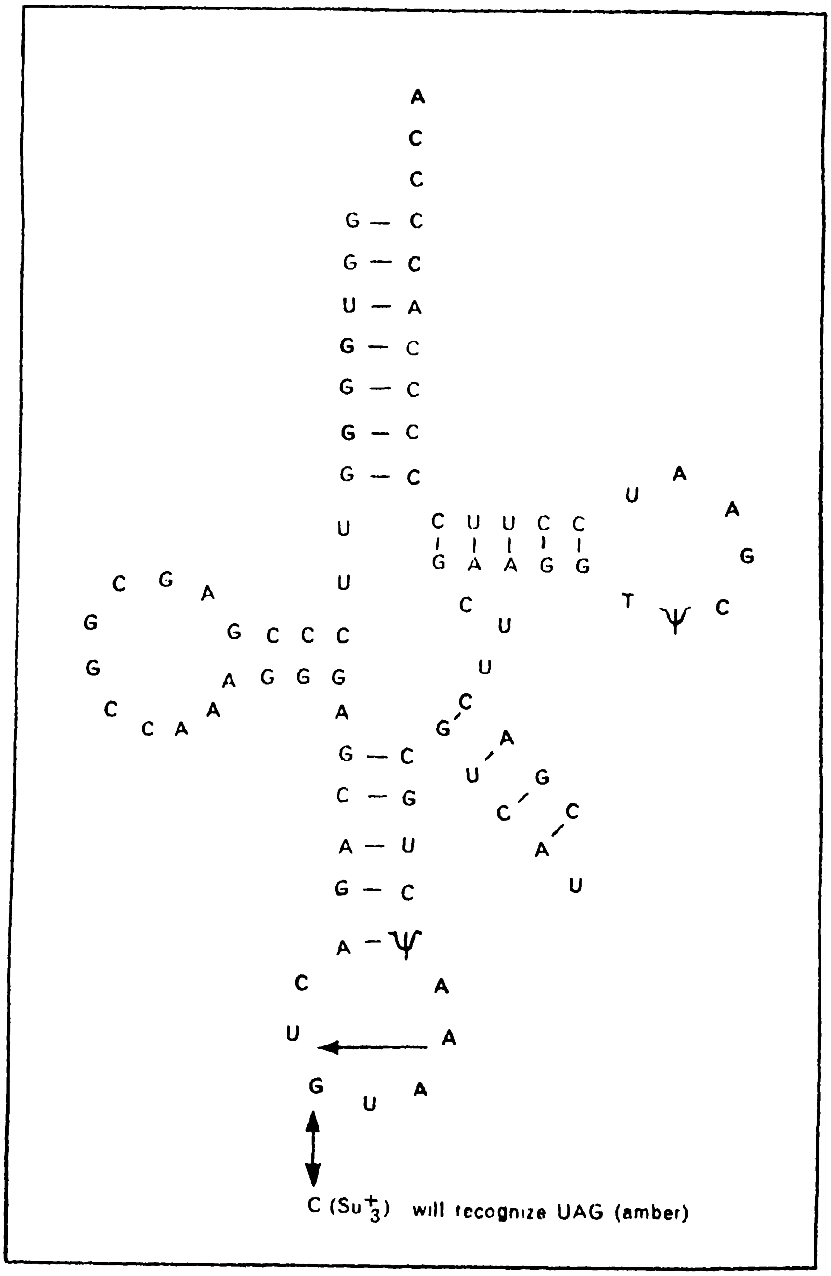

Fig. 3. Structure of an *Escherichia coli* suppressor tyrosine *t*-RNA and its suppressor *t*-RNA suppressing UAG

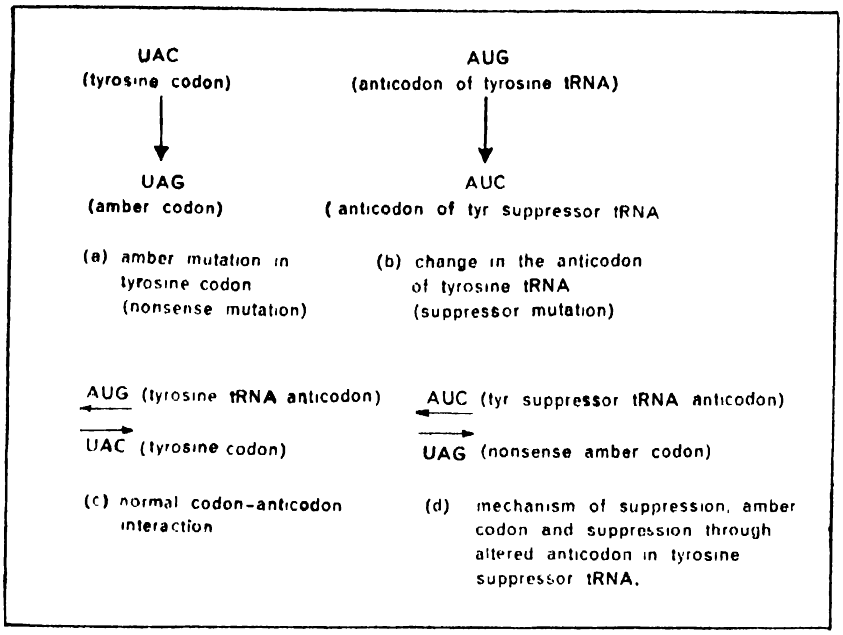
UAC
(tyrosine codon)
UAG
(amber codon)
AUG
(anticodon of tyrosine tRNA)
AUC
(anticodon of tyr suppressor tRNA
(a) amber mutation in tyrosine codon (nonsense mutation)
(b) change in the anticodon of tyrosine tRNA (suppressor mutation)
AUG (tyrosine tRNA anticodon)
UAC (tyrosine codon)
AUC (tyr suppressor tRNA anticodon)
UAG (nonsense amber codon)
(c) normal codon-anticodon interaction
(d) mechanism of suppression, amber codon and suppression through altered anticodon in tyrosine suppressor tRNA.

Fig. 4. Tyrosine *t*-RNA suppressing mutation in tyrosine codon

mechanism of suppression in Fig. 4. It can be noted that a guanine residue in the normal tyrosine *t*-RNA anticodon has been replaced by cytosine residue to give rise to tyrosine suppressor *t*-RNA, so that the anticodon is now AUC which can base pair with amber codon (UAG).

In most of the amber and ochre suppressor mutations (ochre suppressors are however rare), the suppressor *t*-RNAs have an altered structure in the anticodon region. However, Dr. D. Hirsh of the Medical Research Council Laboratory, Cambridge has recently found that in a suppressor mutation, suppressing the termination codon UGA, the tryptophan suppressor *t*-RNA has a single base alteration not in the anticodon region but at the 24th position in the *t*-RNA. How such a change will enable the *t*-RNA to read the codon UGA is not known, but it is obvious that codon-anticodon reaction is not governed by simple rules of base pairing (Fig. 5).

With the discovery of these suppressor *t*-RNAs it became difficult to understand how the termination of polypeptide chains in systems carrying the suppressor *t*-RNAs would take place. If these suppressor *t*-RNAs are present, the termination codons will ordinarily be read and the polypeptide chains will keep on elongating indefinitely. Therefore, an alternative mechanism for the termination of the polypeptide chains should be available. Cases are now known where two termination codons are found in the sequence at the stop signal so that, if one termination codon is suppressed, the other may still function as the termination codon. It was also found that although UAG (amber) and UGA can be efficiently suppressed, UAA (ochre) is suppressed only poorly if at all. Suppression of a particular nonsense codon would mean that it cannot be an efficient termination codon. That is why ochre (UAA) codon which is poorly suppressed is considered an efficient terminator. In phage-R17 it was found that UAA-UAG sequence is present at

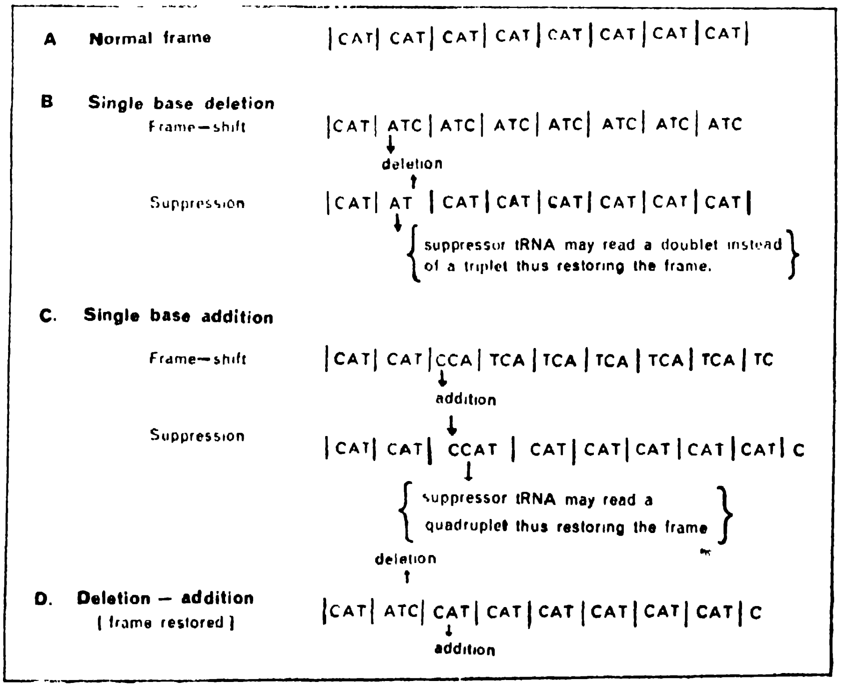
A Normal frame
|CAT| CAT| CAT| CAT| CAT| CAT| CAT| CAT|
B Single base deletion
Frame—shift
|CAT| ATC| ATC| ATC| ATC| ATC| ATC| ATC
deletion
Suppression
|CAT| AT | CAT| CAT| CAT| CAT| CAT| CAT|
suppressor tRNA may read a doublet instead of a triplet thus restoring the frame.
C. Single base addition
Frame—shift
|CAT| CAT|CCA| TCA| TCA| TCA| TCA| TCA| TC
addition
Suppression
|CAT| CAT| CCAT | CAT| CAT| CAT| CAT| CAT| C
suppressor tRNA may read a quadruplet thus restoring the frame
deletion
D. Deletion — addition
(frame restored)
|CAT| ATC| CAT| CAT| CAT| CAT| CAT| CAT| C
addition

Fig. 5. Frame-shift mutations and possible mechanisms of *t*-RNA-mediated suppressions

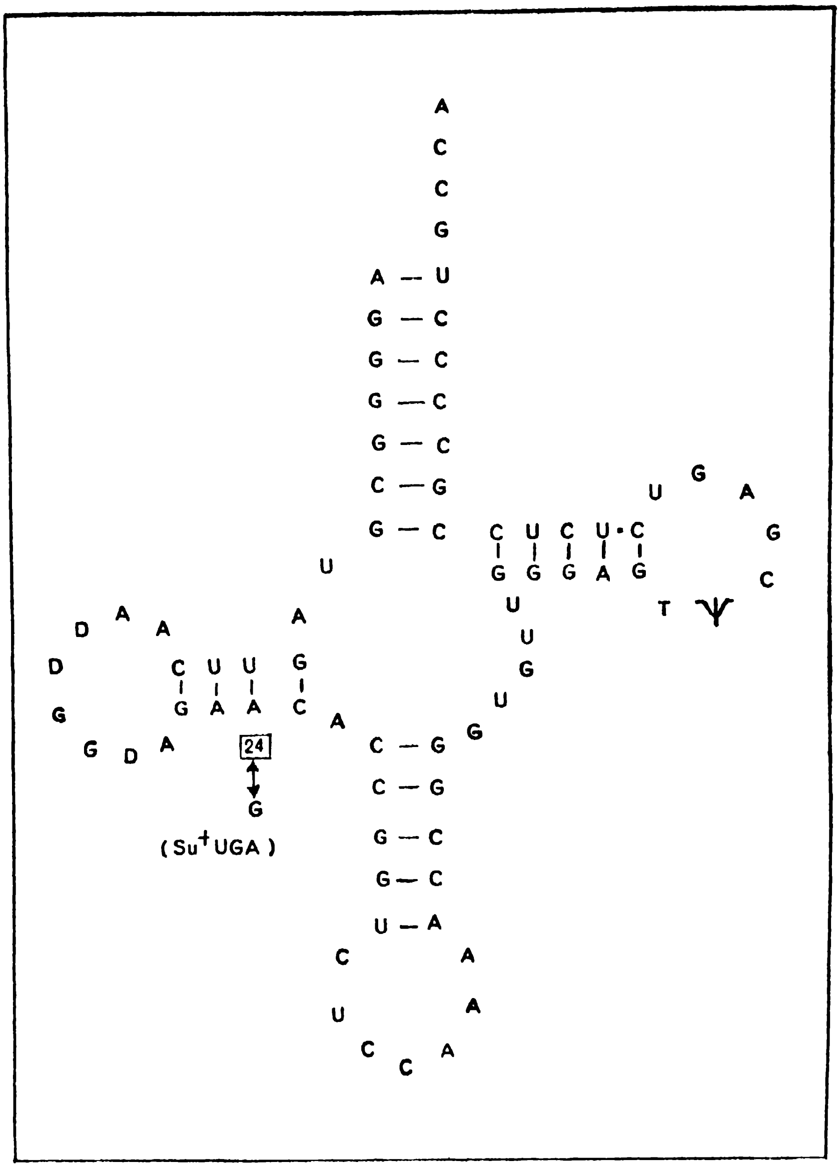

Fig. 5. Structure of *E. coli* tryptophan *t*-RNA and the change at 24th position in UGA suppressor *t*-RNA

the end of the coat protein *m*-RNA. In such a case if one termination codon fails to bring about termination due to suppression, the other codon will still be able to bring about the termination.

Mis-sense mutations and suppressor t-RNAs. When a mutation is brought about in a codon due to base substitution, the resulting codon may code for a new amino acid. Such a mutation is different from the nonsense mutation and is called mis-sense mutation. This has recently been observed in a mutation of the tryptophan synthetase, a gene in which glycine was replaced with arginine, thereby giving rise to an inactive enzyme. Suppressor mutations are now known which cause insertion of glycine at the new arginine site so that an active enzyme is synthesized. The efficiency of suppression however being low, both active as well as inactive forms of the enzyme are synthesized.

In *in vitro* experiments, where regular copolymers $(AG)_n$ (as those employed by Dr. Hargobind Khorana in the study of the genetic code) were used as *m*-RNA, a polypeptide chain was found to be synthesized which included glutamic acid and arginine. However, when *t*-RNA extracts from suppressor mutants were used, glycine was also incorporated in the polypeptide chain. The level of glycine incorporation corresponded well with *in vivo* suppression. On chromatographic analysis suppressor *t*-RNA and glycine *t*-RNA are found at the same place indicating that the change is rather minor. This change could be in the anticodon region only. The detailed structure of glycine suppressor *t*-RNA has not been worked out so far.

Frame-shift mutations and suppressor t-RNAs. Frame-shift mutations, as pointed out earlier, are the result of deletion or addition of single bases. In these mutations the entire sequence of amino acids beyond the point of mutation is disturbed.

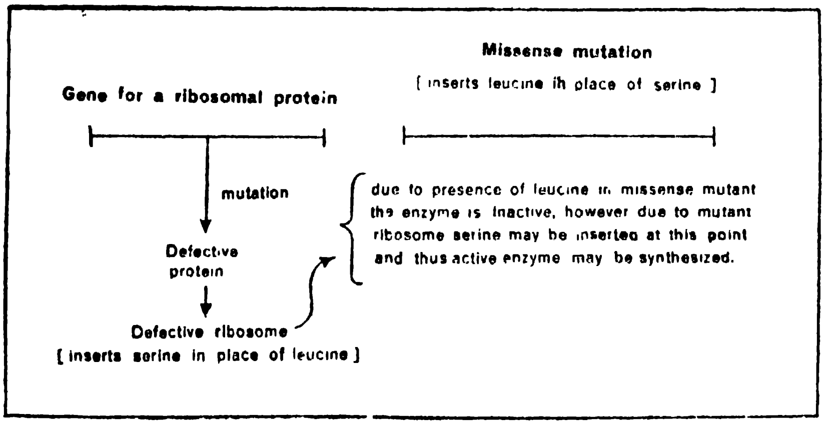
Gene for a ribosomal protein
mutation
Defective protein
Defective ribosome
[inserts serine in place of leucine]
Missense mutation
[inserts leucine in place of serine]
due to presence of leucine in missense mutant the enzyme is inactive, however due to mutant ribosome serine may be inserted at this point and thus active enzyme may be synthesized.

Fig. 7. Suppression of mis-sense mutations through ribosomal mutations

Suppressors for frame-shift mutations are also known today. It has been shown that such suppressions are perhaps brought about through the presence of some altered *t*-RNAs, because these suppression mutations are located where the gene for one or the other *t*-RNA is found. However, crucial proof of this will come only after the suppressor *t*-RNAs are isolated from the mutant strains. Some progress in this direction has already been made.

The structure of none of the suppressor *t*-RNAs suppressing frame-shift mutations could be worked out so far, but whenever it is done it will give an idea about the mechanism of frame-shift suppression. It is, however, presumed that these suppressor *t*-RNAs may work by reading doublets (2 bases) or quadruplets (4 bases) thus restoring the frame. The nature of the frame-shift mutations and the possible mechanism of *t*-RNA-mediated suppression is illustrated in Fig. 6.

Suppressor *t*-RNAs and good genes

The suppressor *t*-RNAs synthesised under the control of suppressor genes will not only cause suppression of the mutant gene, but will also misread other good genes and affect synthesis of all proteins. If the altered form of *t*-RNA, i.e., suppressor *t*-RNA is the only form avilable for that particular amino acid, the normal proteins containing that amino acid would never be synthesised. Due to this reason perhaps, for a particular amino acid, ordinarily a major and a minor *t*-RNAs are available. For instance, the major and minor *t*-RNAs for tyrosine are known. Both these tyrosine *t*-RNAs have the same anticodon 'AUG' but differ in other bases. The role of these minor *t*-RNAs is not known but it has been found that they are invariably involved in the formation of suppressor *t*-RNAs so that the major *t*-RNA for this amino acid is still available for normal function.

Suppressor and ribosomal mutations

It should, however, be pointed out here that the suppression is not always brought about through suppressor *t*-RNAs. It may also be brought about through ribosomal mutations where a change in one or other ribosomal protein is brought about. Such a change affects the accuracy with which codon-anticodon interaction works and results in the misreading of a particular codon. Therefore if a mis-sense mutation occurs in a particular gene, the mis-sense codon may be misread by the defective ribosome inserting the correct amino acid at the point of mutation (Fig. 7).

Cases are also known where suppression of frame-shift mutation was brought about through a change in a ribosomal protein. It is suggested that such modified ribosomes may help normal *t*-RNA to read a doublet or a quadruplet (see Fig. 6) so that the normal frame may be restored.

It may therefore be concluded that there can be different mechanisms involved in the action of suppressor mutations, but perhaps the most common is through the suppressor *t*-RNA and less common is through the mutations in ribosomal proteins. Besides these, other mechanisms may also be involved.

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INFRARED SPECTROSCOPY *(Continued from page 484)*

Thus infrared spectroscopy has provided physicists and chemists with an extremely elegant and powerful tool for the elucidation of molecular structure. Let us hope that in the long run the fundamental use will be more exciting and informative. IR spectroscopy has emerged to be a great blessing not only to analytical chemists, workers in the chemical industry and to medical researchers but also to IR spectroscopists interested in fundamental chemistry.

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INFRARED SPECTROSCOPY AND ITS APPLICATIONS

C. L. GUPTA

IR spectroscopy has provided physicists and chemists with an extremely elegant and powerful tool for the elucidation of molecular structure

THE infrared absorption spectra of a molecule is highly characteristic and often has been referred to as a molecular 'fingerprint.' The usefulness of an absorption infrared spectrum for identification and chemical analysis was recognised in the early 1900s, when the American physicist William W. Coblentz determined the infrared spectra of hundreds of substances and clearly demonstrated their potential value.

Infrared spectra originate from the different modes of vibration and rotation of a molecule. In 1914, a Danish chemist, Niels Bjerrum, showed that vibrational behaviour of a molecule may be accounted for correctly if its atoms were regarded as small masses and the bonds holding them together as springs. The response of atoms to a light wave is much like the response of cork balls, floating on the lake, to waves. As waves move past the balls the latter are pushed alternately up and down. Similarly, when a light wave passing through an atom sweeps an oscillating field over it and if the atom carries an electrical charge, it will be pushed first to one side and then to other. In a hydrogen chloride molecule, the hydrogen carries a small positive charge and the chlorine atom a corresponding negative charge. Because these two atoms carry opposite charges, the electric field of a light wave tends to set them into oscillation, stretching and compressing the H-Cl bond alternately. It follows, therefore, that the charges on the ends of the molecule will oscillate as the molecule vibrates.

The bond has a natural frequency of vibration depending on the masses of the two atoms and the restoring force of the bond. A light wave of the same frequency will have effect on the bond most, as its energy will greatly increase the natural vibration of the atoms. The irradiated molecule will absorb a part of the energy of the light as its resonant frequency which will be indicated by an absorption peak. The above, of course, is a very simplified picture, as no consideration has been made for the influence of the rest of the molecule. Many absorption peaks of weaker intensities occur at shorter wavelength. These are known as overtone and combination bands.

It must be borne in mind that for a vibrational mode to appear in the infrared spectrum and absorb energy, it is essential that there must be a change of electrical symmetry or dipole moment during vibration. Vibration of two similar atoms against each other, say of O_2, N_2, or Cl_2 molecules, will not result in a change of molecule's dipole moment and hence such molecules will not absorb in the IR region. One of the modes of vibration of CO_2 molecule also does not absorb energy due to the above reason.

Bond vibration modes are of two distinct types: stretching and bending (deformation) vibrations. The former constitutes the periodic stretching of the bond along the bond axis and the latter involves dispalcements occurring at right angles to the bond axis (Fig. 1). For a polyatomic molecule there will be several basic ways in which the molecule can vibrate. Different vibrational modes lead to corresponding vibrational energy patterns.

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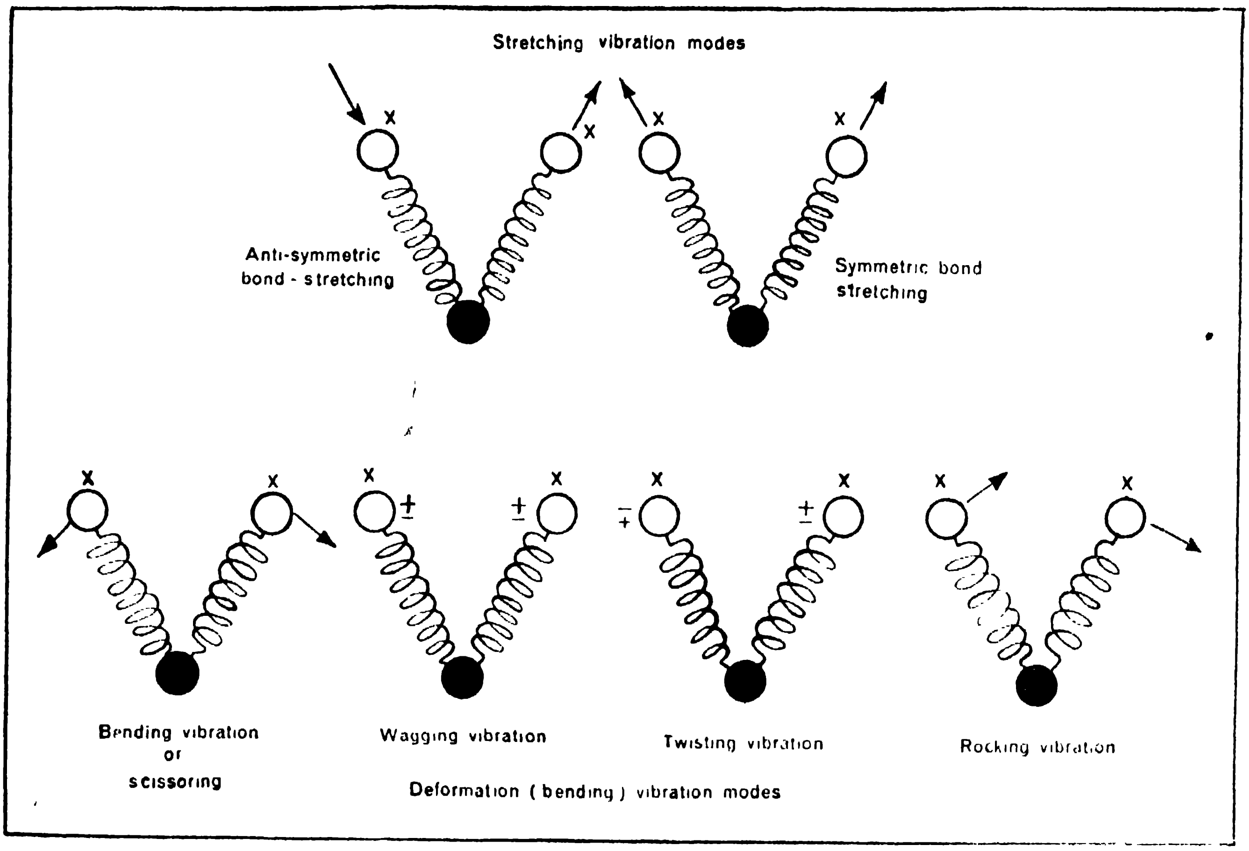
Stretching vibration modes
X
Anti-symmetric bond - stretching
Symmetric bond stretching
Bending vibration or scissoring
Wagging vibration
Twisting vibration
Rocking vibration
Deformation (bending) vibration modes

Fig. 1. Types of vibrations that cause most absorption bands. Plus and minus signs indicate motion of X-atom in and out of plane of page respectively

Instrument design

IR absorption spectra are recorded by IR spectrophotometer (Fig. 2). IR radiation emanating from a source (*A*) is split into two beams after reflection from two pairs of mirrors. One of the beams passes through an optical attenuator (wedge *B'*), whose transparency can be adjusted. The other one is the sample beam. A rotating mirror or diaphragm (*C*) passes the two beams by way of a pair of mirrors alternately to the curved mirror (*D*) which reflects them to the prism. The prism disperses the emergent beam into its different wavelengths. A rocking mirror (*E*) sweeps these separated wavelengths across a detector. The strengths of the alternately received beams are compared at successive wavelengths. When equal light energy is transmitted by both sample and reference beams, no signal is produced at the detector. The absorption by the sample beam results in inequality of the two transmitting beams falling on the detector which produces a pulsating electrical signal. The frequency of the signal is equal to splitting of the beam by the rotating mirror (*C*). This is amplified electronically and is used to drive a servo-motor. The motor moves the optical wedge (*B'*) on to or out of the reference beam to equalise or nullify beam intensities. Since the recorder pen is coupled directly to the optical attenuator, its movement is a record of the wedge position or transmittance. The instrument thus provides a continuous record of IR transmittance of a sample against wavelength of incident radiation. The rotational position of the drum relative to the pen designates a particular wavelength, and the position of the pen along the drum axis is proportional to the transmittance at that wavelength. The principle of beam-balance ensures greater accuracy by eliminating errors arising due to variation in the radiation source and the detector. An additional advantage of double-beam operation is elimination of signal variations due to change of amplifier gain.

The material most generally used for prisms, cells to hold the sample to be placed in the radiation beam, and lenses, etc., for IR measurements in the different regions is rock-salt, i.e., NaCl. Other salt crystals such as LiF, CaF and KBr are also used for special purposes. Since some of the above materials are soluble in water, the instruments must be carefully protected from high relative humidities.

The design and function of various components of a spectrophotometer are described below.

Source. IR radiation is produced by heating either a Nernst filament, or 'Globar'. The Nernst filament—also known as Nernst glower—is a tubular filament of high resistance, composed chiefly of powdered, sintered oxides of zirconium, thorium and cerium held together by a binding material. The 'Globar', which is a trade name, is nothing but a rod of silicon carbide or any other suitable material. These are heated to temperatures in the range of 1200-2000° C to produce IR radiation. Tunable laser sources hold promise for the future.

Detector. The most frequently used detectors are the thermocouple and the bolometer. The whole system of thermocouple is enclosed in an evacuated vessel in order to avoid loss of energy by convection. The vessel is provided with a window transparent to IR radiation.

A bolometer is essentially a thin blackened platinum strip in an evacuated glass vessel with a window for receiving IR radiation. It is connected to one arm of a Wheatstone bridge. Two such identical elements usually form the opposite arms of a bridge. One of the elements when placed in the path of IR beam absorbs radiation. The absorption consequentially changes the resistance. Both the above devices give a very feeble direct current which after manifold amplification may be utilised to drive a recorder.

Some instruments use a Golay pneumatic detector. This consists of a gas-filled chamber which undergoes a pressure rise when heated by radiant energy. Pneumatic detectors are satisfactorily used over a wide frequency range.

Attenuator. These vary in shape from combs or wedges to rapidly rotating toothed star wheels.

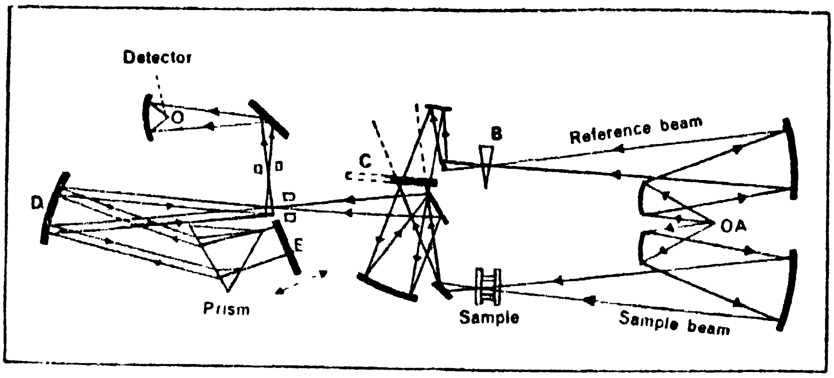

Fig. 2. Infra-red spectrometer

Recorder. Except in Zeiss UR-10 spectrophotometer, which gives a needle trace on a waxed paper, all other instruments record the spectra as a pen trace on a paper chart. Movement of the pen is synchronized with attenuator motion while the chart itself is moved at right angles to the pen on a rotating cylinder. The rocking mirror can be controlled by a single motor.

Cells and sampling techniques

IR spectra of both liquids and gases are obtained by direct study of the undiluted specimen. However, the study of solids is made after dispersing them in one of the suitable media. Description of various cells and the standard sampling procedures are outlined below for each type of phase.

Crystalline phase spectra

Crystalline solids may be investigated in a number of ways as given below. In all the techniques, solid is ground to very small particles. The different techniques generally employed are:

Mull technique. For 'mull', a viscous liquid such as a good mineral oil Nujol (a high-boiling fraction from petroleum) is generally used. Fluorolube (perfluoro-kerosene, a mixture of fluorinated hydrocarbons) and hexachlorobutadiene have been employed as mulling agents when it is desired to study the wavelength range in which Nujol absorption bands appear. In this technique, 2-5 mg of the solid mixed with a mulling agent is ground in a pestle and mortar. The suspension is then transferred to a rocksalt plate. The mull is again covered by a second plate pressed lightly to spread the mull as a thin film. Thereafter, the plates are retained in a cell plate holder in the sample-beam path of the spectrometer. This arrangement is illustrated in Fig. 3.

Pressed disc technique. The technique consists of grinding a few milligrams of the solid with about one gram of pure, finely powdered potassium bromide. The mixture is then compressed under high pressure in the range of 10,000—50,000 lb per square inch. This results in a clear and nearly transparent disc which is mounted in a holder and supported in the IR beam.

Solid deposit technique. In this method samples are obtained by depositing the solid on a plate surface from a concentrated solution. A concentrated solution is allowed to evaporate on a plate surface, which leaves ultimately an even layer of solid as a glassy film. To obtain correct form of deposits a large number of solvents or mixture of solvents are tried for making the solution of a solid.

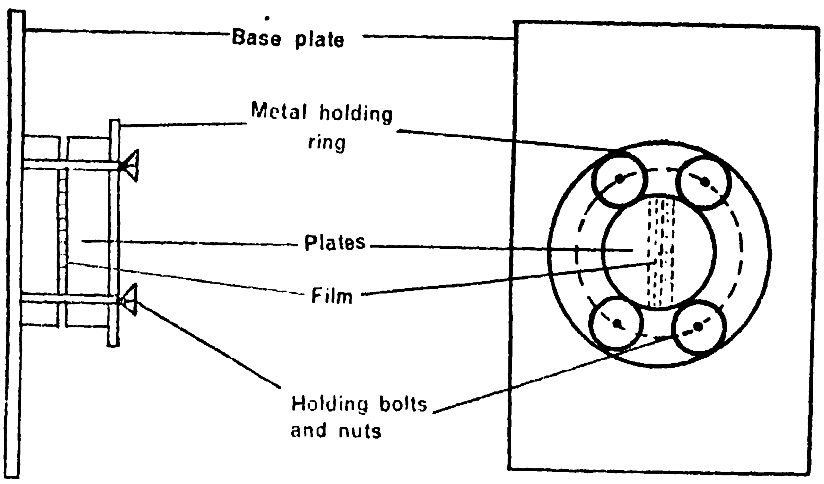

Fig. 3. Typical plate assembly and holder

Liquid phase spectra

Three different types of liquid cells include the demountable type, the fixed thickness type, and the variable space type. The demountable cells are those in which separate components are assembled by the operator for each spectra. It is of the sandwich type and is provided with a set of several circular lead spacers. Windows of rocksalt are clamped in place. Volatile liquid cannot be handled in such cells.

The fixed thickness cells have a lead-amalgamated gasket compressed between the plates. Narrow inlet and outlet ports are drilled through both the metal and the halide top plates for injection of the solution into the cavity. Plastic stoppers keep the solution within the cell.

The variable-space type cells consist of two salt plates whose gap may be varied by means of a micrometer screw.

Applications

Most of the applications of IR absorption spectra concern with the organic compounds because water, the chief solvent of inorganic compounds, absorbs strongly beyond 1·5 micron (1 micron = 10^{-4} cm). In addition to it, inorganic compounds often have broad absorption bands, whereas organic substances give rise to several narrow bands. Following are some of the applications of IR spectra.

Qualitative chemical analysis. Qualitatively, IR spectra may be used for the following purposes:

(1) The IR absorption spectrum of a compound may be regarded as a 'fingerprint' of that compound. Thus to identify a pure chemical compound, the spectrum of the unknown is compared with previousely recorded spectra of possible substances suggested by other properties. This procedure is especially valuable for distinguishing the various isomers of a compound.

(2) The spectra of a mixture of compounds is essentially that of the sum of spectra of individual components; provided association, dissociation, polymerisation, or compound formation do not take place. Therefore, to detect an impurity in a substance its spectrum its compared with that of the pure compound. The spectra of impurities will appear as extra absorption bands.

(3) It has been known that certain groups of atoms, the so-called functional group in a molecule, have characteristic natural frequencies that are relatively independent of the rest of the molecule in which the group is present. Therefore, the presence of such functional group may be ascertained in a certain molecule.

Quantitative chemical anaylsis. This type of analysis by IR is possible due to the fact that there exists a quantitative relationship between absorbance and the number of abosrbing molecules.

Study of solid state. IR spectra are often used by solid state physicists to elicit information about modes of vibration of crystal lattices, hydrogen-bond vibrations in crystals held together by such bonds, and energy-levels in semiconductors and superconductors.

Reaction kinetic studies. IR spectroscopy may be utilised to measure the rates of reaction by ascertaining the consumption of starting materials and appearance of products. A spectrophotometer is switched on to record a series of curves by repeated scanning over a pre-selected range at regular intervals. Actually, reaction kinetic studies are specific cases of quantitative chemical analysis. Similarly structure of molecules may also be determined to varying degrees of refinement from IR spectra.

The much importance attached to IR spectroscopy is because even isomers which have the same atoms and the same bonds but different arrangement can be distinguished. Even slight structural difference can give rise to profound difference in biological activity. Since most of the biological phenomena are highly sensitive to such differences in compounds, IR spectroscopy is a very important tool for a medical investigator. Internal combustion engines are sometimes sensitive to isomeric differences. The difference between 'knock' and 'antiknock' gasolene compounds is a problem well-suited for the IR spectroscopy in the petroleum industry.

(*Continued on page 480*)

CAGE CULTURE OF FISHES

NIRMAL K. THAKUR

Compared on the basis of weight gain per unit area used and per unit of time spent, fish culture in cages surpasses all other systems of culture

FISH culture in cages has gained tremendous popularity in Japan recently and is being intensively practised for culturing both freshwater and saltwater species of fishes. The cultured fishes are of highly esteemed varieties like yellow-tail (*Seriola quinqueradiata*) and sea bream (*Chrysophrys major*). Production of fish from floating cages alone amounts to over 90% of the total lot produced from the culture in shallow seas.

Why cage culture ?

Culturing fish in cages has obvious advantages. It requires less investment than do fish ponds on land and its installation is easy. In emergencies it can be removed from one place to another. Inspection of fish in cages at each feeding is an advantage that every pond owner would like to have. Also the treatment of diseases in cages is much simpler than in ponds. Cage culture provides an opportunity for controlled culture of choice fish and their non-seasonal supply. Harvesting of fish in cages is no problem at all and the cost, therefore, on labour and gear is considerably reduced.

Sites for cage culture

The best suited sites for culture of fish in cages are those bodies of water that cannot be readily manipulated for harvesting by the usual drain-and-seine method. In Japan for the cage culture of carps (*Cyprinus carpio*) or any other variety of freshwater fish, standing waters such as lakes, reservoirs, and slow flowing streams without high waves are considered ideal sites. The broken nature of the coast line enables Japan to have numerous sheltered inlets providing plentiful areas of calm waters for culturing marine fishes. The Seto Inland Sea, lying between the isles of Honshu in the north and Shikoku in the south, is one of the calmest regions where cage culture has been flourishing.

Ponds of adequate sizes are also utilized for raising fish in cages. The area required for cage culture is only a small fraction of the total area of the pond and does not interfere with its normal use. If a pond has high degree of fertility but low oxygen content during summer, it might be difficult to use cages in that particular pond. It is because fish let loose in a pond can survive low oxygen concentration better than do fish in a cage. Fish in a pond can come to the surface layer of water saturated with oxygen but those in a cage do not have enough water surface available. Such oxygen depletion, however, is no problem if air-breathing fishes (*Anabas*, *Heteropneustes*, *Clarias*, *Notopterus*, murrels, etc.) are chosen for cage culture in such waters. The air-breathing fishes, as the name suggests, are able to breathe air in addition to their normal gill respiration and thus can survive in waters deficient in oxygen.

Cage construction

There is no particular design of a cage which is best in all situations.

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Cages should be constructed according to the prevailing conditions. In east Asian countries, for example, cages made of bamboo mats are most suitable. In the United States, on the other hand, cages are generally constructed with a variety of galvenized welded wires and nylon meshes. These cages are made to float by a series of styrofoam blocks. The design and construction of cages used in Japan are actually a modification of the sardine net cages which are used by the skipjack angling boats along the Pacific coast for keeping live sardines as baits. Basically, a cage is a flat-bottomed net made of synthetic materials (polyamide, polyester, polyethylene, polyvinylidene chloride, polyvinyl alcohol, etc.) which opens on the water surface. The cage is shaped by long bamboo poles into a square or any other desired shape and is kept afloat by a number of steel drums serving as floats. For fixing a cage in a pond or where the water depth is not too deep, it is tied by wires to four heavy wooden stakes driven into the pond bottom. The use of floats in such waters can sometimes be eliminated by tying the cage directly to the fixed stakes. But this method is effective only at places where the water level does not fluctuate. In deeper waters or where water level fluctuates, cages arranged in rows are kept afloat and are fixed at a suitable site by means of heavy anchors.

Commercial fish farms use steel frames for shaping the cages in place of bamboo poles. Steel frames not only make the cages look sophisticated but at the same time they make them stronger and more durable. Japan today has many leading net manufacturers who are making synthetic nets for constructing cages. These nets are specially processed to retain their weaves and shape even under strain and to serve satisfactorily for long periods of three to four years. To minimize the cost of cage construction, steel drums are being gradually replaced by synthetic floats. In order to prevent fish from jumping out, usually a low wing net is attached all round the upper rim of the cage.

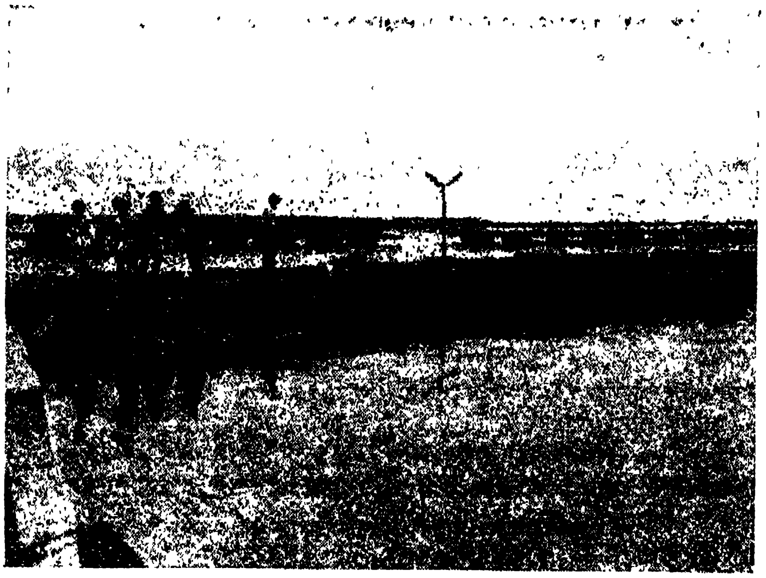

Fig. 1. A cluster of rows of floating cages anchored at one of the sheltered inlets in the area of Seto Inland Sea

Depending upon the requirement, the dimension of a cage can vary from a minimum of a few square metres in surface area to a maximum of whatever one wishes to handle. A surface area of 8-12 square meter is the usual standard size in which cages are constructed in Japan. As for the depth, in case of carp culture two metres has been recommended as the most ideal one. For the culture of saltwater variety of fishes in shallow sea, a depth of 3 to 5 meters is favoured.

A mesh-size smaller than 1½ inch retards water circulation in cage. The fishes as well do not grow larger in size. The probable reason for this is that a fish in water that has faster circulation receives a greater amount of oxygen and there is greater degree of muscular activity than in the fish in water with retarded circulation.

Stocking in cages

Cages fixed in larger water bodies such as lakes, reservoirs, shallow seas, etc., have better and more favourable environmental conditions, *viz.*, smaller temperature fluctuations and higher concentration of dissolved oxygen. Thus, a larger number of fish can be stocked in a cage than in a pond of the same size.

Generally, because of the bigger mesh size, fingerlings or more grown up fishes are used for stocking in cages. Smaller-sized fishes prior to stocking, therefore, are reared in cages with smaller mesh size. Rate of stocking in cages depending upon the size, growth and behaviour of the fish varies from species to species. In Cambodia, for example, a cage 7-10 m long, 2·5-4·5 m wide and 1·5-2 m deep carries about 7000 to 8000 young *Pangasius* fish each about 80-150 gm. For cage culture of channel catfish (*Ictalurus punctatus*) in U.S.A., Dr. Collins of the State College of Arkansas has recommended a stocking rate of 300 (six inches in size) per cubic yard of water and suggested the possibility of raising them to an average weight of one and a half pounds each in a growing period of 180 days with regular artificial feeding. In Japan, for carp culture in cages the standard stocking

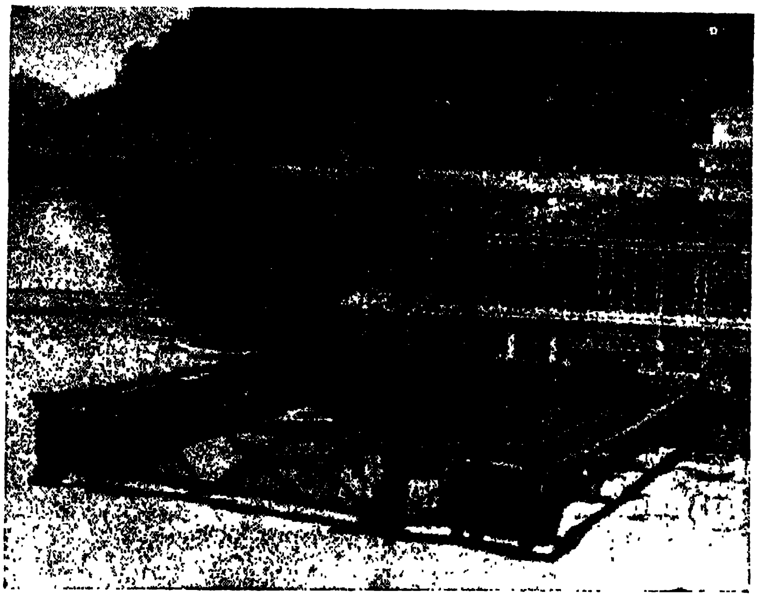

Fig. 2. A floating cage showing use of steel frames and synthetic floats

rate is about 50 fish/m^2 surface area of the cage, i.e., 500,000 fish/hectare. However, experiments in this regard with various stocking rates, ranging from 30-70 fish in 10-50 g/m^2 surface area of water, have revealed that larger nets and longer periods of operation result in higher production of fish.

Feeding programme

Apart from the rate of stocking and water temperature, the two principle growth determining factors for the stocked fishes in cages are the type of food supplied and the quantity fed. For the regular supply of artificial feed, culturists have to depend upon feed manufacturers. Japan today has many such manufacturing units producing various kinds of feed in pellet forms based on latest formulations. These pellets are produced with various combinations of ingredients in various sizes prescribed as per the food preference and feeding behaviour of various cultivable fishes. The pellet feed is usually composed of raw materials of animal (about 60%) and plant (about 40%) origins consisting mainly of white fish meal along with liver meal, meat and bone meal, blood meal, skimmed milk, plant protein, rice bran, soybean meal, etc.. Feeding in cages should be so regulated that all the food is eaten up before being washed away.

Trash fish or fish which has less market value such as horse mackerel (*Trachurus japonicus*), anchovy (*Engraulis japonica*), sand lance (*Arctoscopus japonicus*), etc., are also commonly used as feed for fishes in cages, particularly for carnivorous ones such as yellow-tail or sea bream. It has been observed that these fishes prefer their ration of trash fish to be given in sliced form than in minced form. While feeding it is always good to keep fish partly unsatiated. It helps fish to be in good health. The highest feeding effect in case of yellow-tail has been observed at 70-80% of satiety. Any increase or decrease in this amount has been observed to lower the feeding effect. Frequency of feeding in a cage varies from fish to fish. In the case of carp culture, feeding is done 5-6 times a day whereas in the case of yellow-tail two feeds per day have been found adequate. Sometimes light lures are also placed in cages to attract planktonic life in the cage during night which serve as the additional food for stocked fishes.

Harvesting

Harvesting fish from a cage is not a problem at all. It is like fishing in a bowl. Only the cage has to be lifted out of water with a boom and fish emptied into a hauling truck. In bigger cages some kind of handy nets are used to take out the fish. The advantages of harvesting fishes in cages are many. One can catch just the number of fish required. Fishes can, therefore, be harvested during the entire season and in exact quantities that are needed at a given time. It also helps maintain non-seasonal supply of fish.

The production from cages is pretty high in Japan. In the case of carp culture, within five months of growing period (May to October) with intensive artificial feeding, on an average, 30-40 kg of fish/m^2 are harvested. The production rate is 300,000 to 400,000 kg/hectare. The net gain in weight is about 10-12 times. As far as the economics of this method of culture is concerned, a comparison of production of common carp in different types of culture revealed that if it is made on the basis of weight gain per unit surface area used and per unit of time spent, the production per square metre in cages stands second only to that of fish culture in running water and it surpasses all other systems of culture. However, it has been argued that the use of this system of culture cannot be evaluated on such figures alone because each culture method is made possible only by the conditions that permit or demand its adoption.

Scope of cage culture in India

There are vast swampy areas in our country which cannot profitably be utilised for conventional fish culture. This is largely because of their heavy infestation with aquatic vegetation and depleted condition of oxygen concentration.

Recently when these swampy areas were considered on a national level, the attention of our planners was naturally drawn towards organised culture of air breathing fishes in these waters. For this, an All India Coordinated Research Project on culture of air-breathing fishes in swamps has been approved by the ICAR as a central scheme under the Central Inland Fisheries Research Institute, Barrackpore. Realising the advantages of cage culture this Coordinated Project has strongly recommended the introduction of cage culture practice as a possible answer to the problem. Initially the possibilities of cage culture are being explored and techniques are being experimented in Assam, Bihar and Karnatak States. To make cage culture an economic proposition, indigenously available fabricating materials such as split-bamboo mats, bamboo-splints, etc., are being used; and for artificial feeding cheaply available feed such as rice husk, rice bran, pulse husk, mustard oil cake, trash fish kitchen waste, slaughter house waste, etc., are being tried. Certain experiments in this regard have already been encouraging and given hopeful results. It is expected that this production-oriented and employment generating scheme with low subsidy, apart from forming a substantive second line of production in terms of fish protein from the inland derelict waters, will also help in bettering the socio-economic condition of the poor people in India.

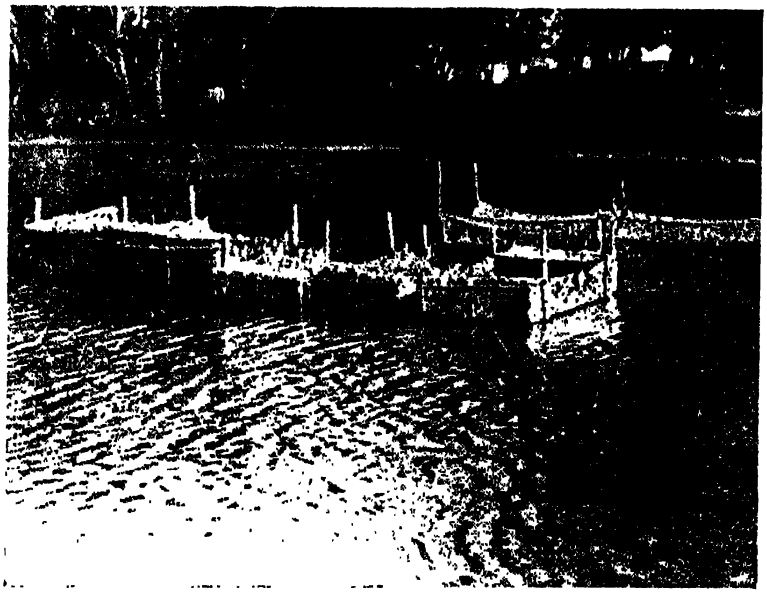

Fig. 3. Split bamboo-mat cages fixed in a derelict pond in North Bihar for the experimental culture of air-breathing fishes

Further reading

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PORPOISES *(Continued from page 505)*

pulsed sound and that they identify themselves to one another and also express emotions by the use of a pure tone whistle.

In the old days porpoises formed an important part of the diet of the whalemen who were at sea for many months. The meat of the porpoises is said to be excellent as it is rich in protein but has an odour somewhat disagreeable to a common man. Besides being edible, the porpoises furnish an oil that is exceptionally useful for lubricating small and delicate machinery, for example, watches and instruments of various kinds. A study of these fascinating mammals may be fruitful for human beings in future.

ZAKIR A. ANSARI

SCIENCE SPECTRUM

Of Pi and Phi

"OF what use", said Kronecker to Lindemann, "is your beautiful investigation regarding π ? Why study such problems, since irrational numbers are non-existent?" And it was this Lindemann, who in 1882, immortalized himself by proving the transcendence of π thus settling the matter of squaring the circle once and for all.

However, π owes its discovery to Hippocrates, a mathematician of the fifth century B.C., who, while studying the properties of the circle, arrived at the result that circles are to one another in the ratio of the squares of their diameters. This is equivalent to the discovery of the formula πr^2 for the area of a circle in terms of its radius. It means that a certain number exists and is the same for all circles, although Hippocrate's method does not give the actual numerical value for π. It is thought that he reached this conclusion by looking upon a circle as the limiting form of a regular polygon, either inscribed or circumscribed. This was an early instance of use of approximation from below and above to a desired limit.

Pi is an irrational number, i.e., it cannot be expressed as a rational fraction. It is the ratio of the circumference of a circle to its diameter. Lindemann, using a method devised in 1873 by Hermite, proved that π is transcendental, i.e., a number which is not algebraic. A transcendental number satisfies no algebraic equation whose coefficients are rational numbers. The existence of such numbers was established by Liouville in 1844 and was first proved by Cantor, much to the astonishment of mathematicians that these are infinitely more numerous than the algebraic numbers themselves.

Various approximations to the value of π are known. An early Egyptian approximation to the area of a sphere is equivalent to reckoning π as 256/81. To seven places of decimals π is 3·1415926. In his work on Differential Geometry, Archimedes had to invoke some algebraic and trignometrical formulae. One such is:

$$\sin\frac{\pi}{2n}+\sin\frac{2\pi}{2n}+\cdots\cdots+\sin\frac{(2n+)\pi}{2n}=\cot\frac{\pi}{4n}$$

Apollonius, writing on 'Unordered Irrationals' invented a 'quick-delivery' method of approximating to the number π. Towards the latter half of the sixteenth century, Vieta, who attacked several outstanding problems that had baffled the Greeks, reduced the problem of squaring a circle to that of evaluating the expression:

$$\frac{2}{\pi}=\sqrt{\tfrac12}\times\sqrt{(\tfrac12+\tfrac12\sqrt{\tfrac12})}\times\sqrt{(\tfrac12+\tfrac12)}\sqrt{(\tfrac12+\tfrac12\sqrt{\tfrac12})}\times\cdots\cdots$$

This was a considerable novelty—the first actual formula for the time-honoured number π which Archimedes had located to lie some where between $3\frac{1}{7}$ and $3\frac{10}{71}$.

It is interesting to give some typical specimens of formulae involving π,

$$\frac{4}{\pi}=\frac{1}{1+1^2}+\frac{1}{2+3^2}+\frac{1}{2+5^2}\cdots\text{(1)}$$

$$\frac{\pi}{4}=\frac{2\times4^2\times6^2\times8^2\times\cdots\cdots\cdots}{3^2\times5^2\times7^2\times\cdots\cdots\cdots}\quad\text{(2)}$$

$$\frac{\pi}{4}=1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\cdots\quad\text{(3)}$$

The first is due to Brouncker, the second to Wallis, while the third was given by Leibnitz, but there is really a special case of a formula discovered by Gregory. They improved on Vieta's formula, not only for their greater simplicity, but because each converges, as Plato would have it, by 'the great and small'—each step slightly overshooting the mark. This is not always done when such sequences are used, as in the more ordinary formula:

$$\frac{\pi}{4}=\frac{1}{4}\text{ of }3.1415926\ldots=\ .785398..$$

which approximates from one side only, like the race of Achilles and the tortoise.

Johann Dase, a calculating "Prodigy at the age of sixteen, was taught by Strasznicky the use of the familiar formula

$$\frac{\pi}{4}=\tan^{-1}(\tfrac12)+\tan^{-1}(\tfrac15)+\tan^{-1}(\tfrac18)+\ldots$$

and was asked thence to calcutate π. In two months he carried the approximation to 205 places of decimals of which 200 were found to be correct.

Euler's contributions are indeed great. Let us have one simple formula he quoted as an epitome of what he achieved:

$$e^{i\pi}+1=0$$

about which Felix Klein remarked that all analyses were centred here! Every symbol has its history—the principal whole numbers –0 and 1; the chief mathematical relations— + and =; e, the base of Napierian logarithms; i, the sign for the 'impossible' square root of minus one, and above all, π , the remarkable discovery of Hippocrates.

We now come to another significant irrational number ϕ, which like π also expresses a ratio—the ratio of the radius of a circle to the side of an inscribed regular decagon; and though not so well known, this ratio, the golden ratio, as it is called—is as interesting as π and besides has an amusing property of popping up where least expected.

If we divide the segment of a line in two parts *a* and *b*, such that

$$\frac{a}{b} = \frac{a+b}{a}$$

then this ratio is ϕ. Taking $b = 1$, we have $a^2 - a - 1 = 0$ which gives:

$$a = \phi = \frac{1+\sqrt{5}}{2} = 1.61803398\ldots.$$

and $a = 1$ makes $b = \frac{1}{\phi} = .61803398$ a unique result, since ϕ is the only number which becomes its own reciprocal by substracting one.

Ancient Greeks were familiar with this golden ratio. There is no doubt that it was used by architects and sculptors particularly in the structure of Parthenon. The American mathematician Mark Barr gave this ratio the name *Phi* after the famous Greek Sculptor Phidies, Father of Archimedes, who used the golden proportion frequently in his work. Perhaps the one reason why Pythagorean brotherhood chose the pentagram or the five-pointed star as the symbol of their order is the fact that every segment in the figure is in the golden ratio to the next smaller segment.

Many medieval mathematicians were intrigued by *Phi* almost to the point of obsession. Kepler called it 'Divine Proportion'. The term 'golden ratio' came in use only in the nineteenth century.

Phi's appearance in various plane and solid figures is fascinating. If the adjacent sides of a rectangle are in this ratio, it is called a golden rectangle. It has the property that if we cut a square from one end, the remaining figure will again be a golden rectangle and this process may be repeated indefinitely. If we place three golden rectangles so that they intersect symmetrically and each is perpendicular to the other two, the corners of the rectangles will mark the twelve corners of a regular icosahedron as well as the centres of the twleve sides of a regular dodecahedron.

A golden triangle is an isosceles triangle that has sides in golden ratio to its base. Each base angle is 72° which is twice the top angle. Such a golden triangle is involved in the construction of pentagram. If we bisect a base angle, the bisector cuts the opposite side in golden ratio to produce two smaller golden triangles, one of which is similar to the original. This process also can be continued indefinitely.

A series of the type 1,2,3,5,8,13, 21....in which each term is equal to the sum of the preceding two is called Fibonacoi series. ϕ is involved here also, as the ratio of any two consecutive terms of this series comes closer and closer to ϕ as the series grows (*note* $\frac{21}{13} = 1.619\ldots$).

As a continued fraction can be expressed as:

$$\phi = 1 + \frac{1}{1+}\,\frac{1}{1+}\,\frac{1}{1+}\;\ldots.$$

while another expression is:

$$\phi = \sqrt{1+\sqrt{1+\sqrt{1+}}}\ldots.$$

In recent times an enormous literature has been developed around ϕ. A German book *Der Goldene Schnitt* (1884) by Adolf Zeisin argues that the golden ratio is the most artistically pleasing of all proportions and is a key to the understanding of all morphology (including human anatomy), art, architecture and even music. Among other books may be mentioned Colman's *Nature's Harmonic Unity* (1913) and Cook's *The curves of Life* (1914). Hambidge (1924) wrote many books on 'Dynamic Symmetry' giving applications of geometry to art and architecture in which ϕ plays a leading role.

Gustav Fechner, a German Psychologist, measured thousands of windows, picture-frames, playing cards and checked the points at which grave-yard crosses were divided and found that the average ratio is close to ϕ, the most pleasing being the golden rectangle.

More recently, in a study the heights of 65 women were measured and the figures were compared to the heights of their navels. The ratio was 1.618. The subjects whose measurements did not fall within this ratio, were "testified to have had hip-injuries or other deforming accidents in childhood".

C.B.L. VERMA

The changing time

THE earth is spinning on its own axis while it is moving about the sun and these two motions are the causes of the formation of day and year. This is a well-known fact but the question of variations, if any, of the durations of day and year needs proper scrutiny. The time interval between two successive occasions of pointing a particular meridian of earth exactly towards the sun is called a day. That time interval may not be exactly equal to the time for one spin of earth because earth's orbit around the sun not being exactly circular, the earth's speed around this orbit is greater when it is closest to sun than that for its farthest position along the somewhat elliptic path obeying Kepler's laws. Thus a solar day is liable to change throughout the year and the common practice is to consider a mean solar day which is an average for 365 days. In contrast, astronomers have suggested a comparatively invariable day, by defining it as the time interval between two transits of a distant star across a particular meridian of earth and named it as a sidereal day which is nearly four minutes shorter than a mean solar day.

Apart from the annual change in the duration of a solar day there exists another long term change in this duration due to the following reasons. Sun, moon, and to some extent, other celestial bodies may produce gravitational influences on earth resulting in the formation of tides in the water surface on earth or in the atmospheric air enveloping it. The energy that goes into these tides is derived from the kinetic energy of rotation of earth. Thus the total kinetic energy for earth's spin diminishes by this amount of loss of energy, resulting in a slight slowing down of its spin. The rate of slowing down of earth's spin is, however, a very slow process and can only be perceived during the passage of a long time. The consequence of this slowing down of spin is an increase in the duration of mean solar day, the rate of increment of which can be approximately estimated from the observed change in its value during a long period of time. On a search of ancient Sanskrit books it is found in a book written by Ārya Bhaṭṭa sometime in the 5th century that one solar year consists of 365.258 68005 days which may reasonably be taken as fairly correct considering the advanced knowledge of Hindu astronomers of the relevant period. The corresponding figure obtained from recent publications is 365.242 19878 days. A difference of these two figures gives a decrease of 0.016 48127 day or 1,423.9817 seconds during the lapse of nearly 1,500 years from 5th to 20th century. Because the date of publication by Ārya Bhaṭṭa is not known precisely, it is belived that the approximate rate of decrement of the duration of a year is 1 second per year, taking round numbers. As a result of this shortening of a year, the solar days are bound to increase slightly on the basis of a fixed span of time. One mean solar day is thus found to increase by about 2.74 milliseconds per year. This increase tallies with the result of slowing down of earth's spin to some extent.

In addition to the two factors responsible for change in the duration of a solar day, there is also every possibility of a change in the mass of earth or of sun resulting in unpredictable amounts of change in solar day or year. That change is beyond the scope of this study.

Considering the changes in the duration of a year, the International Committee of Weights and Measures have discarded the earlier definition of the fundamental unit of time, second, which was 1/31,556,925.9747 of the tropical year 1900 and finally adopted in October 1967, the following definition:

"The second is the duration of 9,192,631,770 periods of radiation corresponding to the transition between the two hyperfine levels of the fundamental state of caesium 133 atom." This is the present valid definition of a second. Confusions may arise after a long time due to the difference between the duration of a second obtained from the aforesaid frequency of caesium atom and that obtained from 1/86,400th part of a mean solar day because the former is apparently constant while the latter is liable to change during long periods of time. In the year 1970, a difference of 2.6 milliseconds was observed in the duration of a mean solar day as derived from these two methods.

The rule applied to ascertain a leap year is considered next for scrutinization. Every fourth year is a leap year of 366 days which is 1 day more than a common year. This accounts for 365.25 days in an average year. Still some discrepancy remains in the exact number of days in a year. Finally the rule is laid down as follows:

"Every year, the number of which is divisible by 4, is a leap year except the last year of a century which will be a leap year only when its number is divisible by 400 but not divisible by 4,000."

Thus the years 1700, 1800 and 1900 are common years while 1600 and 2000 are leap years. Again 4000 and 8000 are common years. According to this rule, the average number of days per year during the first 4,000 years comes out as 365.24225 days because there are (1000–40+10-1) or 969 leap years and 3031 common years. Consequently a discrepancy of 4.91712 hours will crop up in the course of 4,000 years. No suggestion was offered to bridge the gap between 365.24225 and 365.24219878 days for a solar year.

An attempt may be made to shorten this gap by the following consideration. In modification with the aforesaid rule, a correction factor of 1 day for every 20,000 years is desirable; or, in other words, the last leap year during this period needs a conversion to a common year. Though a school of scientists feel that this attempt will be doubtful in view of variation of earth's speed of rotation in future, it seems that there is no reason in their argument keeping in mind the fact that all reasonings should naturally be based on existing conditions.

SUDHISH K. MUKHERJEE

Phosphors and their uses

CERTAIN minerals on exposure to ultraviolet, x-rays or strong sunlight will glow in dark for sometime after the exposure. This emission of visible light by a substance after exposure to some form of energy is known as luminescence. The luminous dials of watches, wall-clocks and fluorescent lamps contain a coating called phosphor which possesses this property of luminescence. The phenomenon of luminescence is of two types—fluorescence, i.e., the emission of light which occurs during excitation, and phosphorescence, i.e., the emission of light that continues after the removal of the source of excitation. Any luminescent material which is prepared artificially is known as phosphors.

What are phosphors?

Phosphors are naturally occurring minerals or synthetic inorganic substance found in glow worms, fireflies, and other marine animals which impart them the ability to give off "cold light". There are certain minerals which have the peculiar property of glowing with a different colour of light with which they are exposed. Some glow with visible colours when invisible ultraviolet rays are directed against them. These substances known as phosphors can absorb energy of one kind and immediately give it off again in another form. Phosphorescent chemicals are light-sensitive and are usually semi-conductors. A phosphor is composed of a base material or matrix such as the sulphides of the alkaline earth metals (Ba, Sr, Ca, Zn, Cd, etc.) in which a suitable activator is added in low concentration. Addition of traces of impurities promote the luminescent property in the phosphors.

The discovery of phosphors dates back to a chance observation made by an Italian cobbler named Vincentius Cascarolus. He lived in the 16th century and was a believer in alchemy. In the course of a daily walk he found a mineral which was hitherto unknown to him (heavy spar or $BaSO_4$). He ignited this mineral with coal and was astonished to discover that the product glowed in the darkness. It is now established that strongly ignited alkaline earth sulphides owe their phosphorescent property to the presence of heavy metals salts as impurities.

Preparation of phosphors

Phosphors are usually prepared by solid state reactions at high temperatures between compounds of extremely high purity. As mentioned earlier, the sulphides of the alkaline earth metals are notable for their property of glowing for a prolonged period after exposure to light. They store up energy by the excitation of crystal lattice, and subsequently reemit it as visible light over a period of time. They are usually

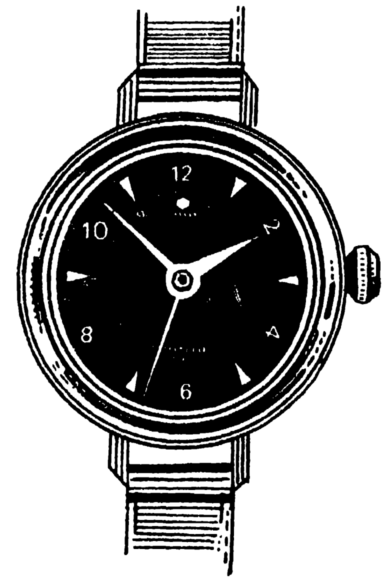


Fig. 2. Luminous dial of a watch

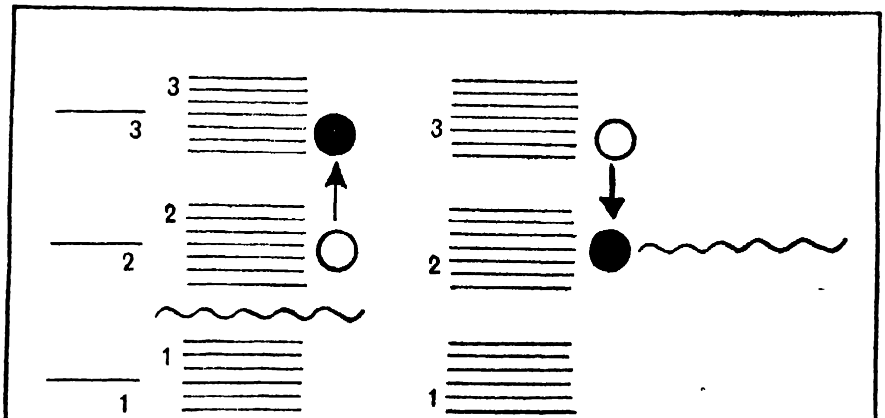


Fig. 1. (*Left*) An electron jumps from a lower orbit to a higher orbit when it absorbs light energy; (*Right*) The excited electron returns to original orbit giving out light which is of longer wavelength than the original ray

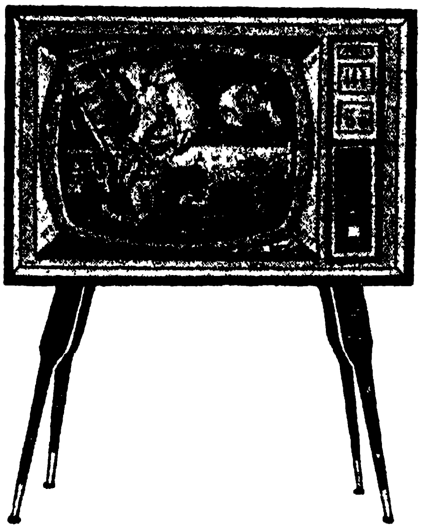


Fig. 3

prepared by igniting alkaline earth sulphides or oxides and carbonates, mixed with sulphur and alkali salts, with suitable additions of very minute amounts of heavy metal salts. For optimum efficiency, ignition is carried out in a special atmosphere which may be reducing, oxidising or inert. Phosphors giving different coloured glows like blue, green, yellow, orange, red, etc., can be made by appropriate choice of alkaline earth metal sulphide, suitable flux, and the impurity.

Excitation of phosphors

There are many ways of exciting phosphors which give off light with different colours. When electrons of phosphors are excited with, say, ultraviolet light (the wavelength of U.V. light is shorter than that of visible light), they absorb this energy and jump to a higher energy level. The electrons do not stay in the higher energy level very long. When they return to the more stable lower energy level, they emit radiation in the form of visible light of lower energy (longer wavelength). Another method of exciting the luminescent materials is to pass a beam of fast moving cathode rays (electrons) on to a phosphor as is done in a television tube. A third method is by the application of an electric field—a phenomenon known as "electroluminescence" (see also *S.R.*, June 1973). The phosphor is sandwitched between two conducting plates and an alternating voltage is applied between them. One of the plates is glass specially coated with transparent tin oxide to make it conducting. The luminescence increases with increase in the frequency of the electric field. The colour emitted by a phosphor depends on the type of phosphor material and on the frequency of the alternating electric field.

Uses

The familiar fluorescent lamp tubes that we see everyday are lined with a phosphor that can receive invisible ultraviolet rays and give off visible light. The phosphor coatings in fluorescent lamps have small additions of antimony and manganese in them which produce a warm white light that does not fall off in brightness with frequent use. Zinc phosphors are used to detect such invisible rays as ultraviolet, x-rays and radioactive emissions like alpha, beta, and gamma radiations. Phosphors find extensive use in television tubes, radar screens, electron microscopes, luminous dials of watches, scientific instrument panels and scintillation counters. Phosphors also find a variety of uses in chemical analysis as tracers in detecting imperfections and defects on the surfaces of cast parts, in spectacular display signs and in many luminescent fabrics and plastics.

Search is going on for newer materials and better techniques for producing luminescent phosphors to suit the wide range of coloured lights and to meet the increasing demands for such products by the industry.

K. SRINIVASARAO

Microorganisms too generate electricity

THE first crucial experiment on bio-electrochemistry was probably performed in 1776, when a visible spark was obtained from the discharge of the fish *Gymnotus electricus*. This demonstrated the truth of Cavendish's deduction that the shocks produced by certain fishes were due to electricity. In 1791 Luigi Galvani discovered electricity in frog muscles. All the earlier work was, however, confined to higher animals. M.C. Potter of U.K. observed for the first time in 1911 association of electric current and potential difference with the oxidation of glucose in the presence of simple unicellular organisms. Disintegration of organic compounds by microorganisms resulting in the production of electrical energy was reported by American bacteriologist B. Cohen in 1931. F.D. Sisler of Environmental Research Institute, Washington, D.C., U.S.A. described a natural biochemical fuel cell system in the ocean. He observed that stray electric currents in the bottom of the sea were caused by microbiological processes rather than geophysical forces such as differential solar heating of the earth.

Microorganisms cause a change in oxidation-reduction (redox) potential or hydrogen ion concentration of a medium by varying the electrochemical activity of the medium and thus forming a biochemical half-cell. As the microorganisms consume substrate, a corresponding reduction in electrode potential in the culture broth occurs. If a sterile medium is connected to this biochemical half-cell, e.g., through a KCL-agar bridge, a flow of current occurs from the lower potential to the higher potential.

There are three basic types of biochemical fuel cells. In the first category are redox cells, where the biological system converts the electrochemical product back into the reactant, e.g., in a cyclic regenerating system involving the biochemical reduction of ferricyanide and the electrochemical oxidation of ferrocyanide. Depolarization cell forms another category where an electrochemical product, such as oxygen, is removed by the biological system. In the third category comes secondary type of biochemical fuel cell where the biological system produces fuels, such as hydrogen or methane, which energize a conventional fuel cell.

Potter employed gold, nickel, tin, zinc, aluminium and carbon as electrodes and measured electrical current by a galvanometer. Working with the culture of yeast in sugar solution and various bacterial species in nutrient media, he obtained the following potentials :

Saceharomyces	—0.32 V
Bacillus coli communis	—0.35 ,,
B. fluorescens	—0.00 ,,
L. violaceus	—0.00 ,,
Sacrino lutea	—0.00 ,,

Unsuitable culture media were belived to be responsible for zero potential of the last three species listed above.

Gaseous hydrogen can also be used instead of glucose as fuel. A thorough investigation of hydrogen evolution has been done in U.S.A. using the organism *Chlostridium welchii.* In earlier trials it had been found that there was a time lag of two to three hours before hydrogen evolution began. Immediate hydrogen production has since been achieved by the use of a large inoculum of freshly harvested 18-hour cells. The best results have been obtained with bananas and cucumbers. The fact that cucumbers, with the lowest carbohydrate content of all the substrates examined, gave a particularly large yield of hydrogen, suggests that substances other than carbohydrates play an important part. It seems probable that natural products which are rich in readily available fermentable sugars, but yield only small amounts of hydrogen, contain other substances which hinder gas evolution.

The performance of cells using biochemically produced hydrogen is limited by the process of collecting and concentrating the hydrogen. The chief advantage of using sugar as a fuel is simply one of convenience.

Enzymes

Enzymes can also be used instead of microorganisms. Since the rate of reaction of an isolated enzyme is higher, a greater power output and efficiency could be achieved.

Enzyme urease which catalyzes the formation of ammonia from urea or urine could be a commercial proposition. In this case, the electrochemical reactant is ammonia obtained from urea or urine. With a battery of 64 such cells an output of 20 watt at 28V could be achieved. In one such study nearly 17g of urea and 13.6 g oxygen per hour were consumed over a working period of two weeks. However, the enzyme urease is expensive and short lived.

The major difficulty with any such enzyme system is the recovery of the enzyme from the reaction medium. This can, however, be overcome by the newly developed technology of attaching the enzyme on some suitable inert solid carrier.

Future applications

About 24% countries of the world, containing 37% of world population, have annual electrical energy consumption of about 20 kWh per capita. At the rate of 50% conversion, human urinary wastes could supply 18 kWh per capita per year which, if feasible economically, would be quite an achievement. Prototype microbial cells have been developed to operate radio receivers and transmitters, sonobuoys, electric lights, small boats, etc.

The limitations of biochemical cells are due to the rapid discharge of biocells under load, unfavourable reaction kinetics leading to sluggish electromotive response. Another reason is unstable and unpredictable nature of microbial or biochemical systems and the intolerable nature of living cells under large electrical charge. But certain organisms have amazing tolerance for electricity. At present various research institutions as well as some commercial organisations are working in this field for its economic utility. A thorough study of microbial electrophysiology will give better insight into the nature of living systems.

PURNENDU GHOSH
VINOD BIHARI

Are chloroplasts autonomous ?

THE green cells of plants contain in their cytoplasm many specialized organelles called chloroplasts. These are usually disc-like or spherical in shape with the average size of 4 to 6 microns. Since their discovery by Von Mohl in the middle of the 19th century, much work has been carried out to enhance our knowledge of these tiny but surprisingly complex organelles. They are the structures where the wonderful process of photosynthesis takes place. It is difficult to imagine life on the earth in the absence of photosynthesis.

Are chloroplasts autonomous, that

is, independent of rest of the cell? If yes, then how much? To what extent do they control their own destination? These are some pertinent questions which need serious thinking and we have to see whether we can answer them in the light of our present knowledge of biochemistry, cytology and genetics.

Cytological autonomy

Botanists knew it long ago that chloroplasts are autonomous; they interact with rest of the cell but are also, at the same time, independent of it to a considerable extent. The cytoplasm was likened to internal micro-environment in which the chloroplasts grew, divided and passed from one generation to another. This idea of chloroplast autonomy first arose as a result of cytological investigations. E. Strasburger (1882) showed for the first time the division of chloroplasts in *Spirogyra*. P.B. Green (1964) studied the division of chloroplasts in *Nitella* and pointed out that the chloroplast division is a much simpler process during vegetative cell division than that during the sexual reproduction. More recently it has been demonstrated that in the zygote of *Acetabularia* one of the chloroplasts from one parent may pair with the chloroplasts of the other (J.C. Crawley, 1966). By now it has been amply clear that chloroplasts of new cells are formed from some part of chloroplasts of the older generation (cells).

As early as 1880, A.F.W. Schimper and A. Meyer put forward a hypothesis that chloroplasts never arise *de novo*. They are formed, without fail, by division of the pre-existing ones and are transmitted from one generation to another during vegetative and sexual reproduction. This classical theory was considered universally accepted till recently when P.R. Bell and K. Mühlethaler (1964) proposed a very bold hypothesis, rejecting the older theory. By means of electron-microscopic study they demonstrated that during the maturation of egg cells in *Pteridium aquilinum*, all the mitochondria and chloroplasts degenerate and get dissolved in the cytoplasm. Atmost simultaneously with these changes they observed protrusions with poor differentiation from the nuclear membrane in the cytoplasm (Fig. 1). On the basis of this they came to the conclusion that during the maturation of egg cells the organelles degenerate, then new organelles arise from the nucleus as protrusions of the nuclear membrane which later separate and develop into new chloroplasts and mitochondria. However, the majority of the workers are of the opinion that evidences supporting the hypothesis of Bell and Mühlethaler are fragmentary and insufficient; and till more data are obtained on the ultrastructure of mature egg cells in a large number of species of plants the classical theory should be accepted.

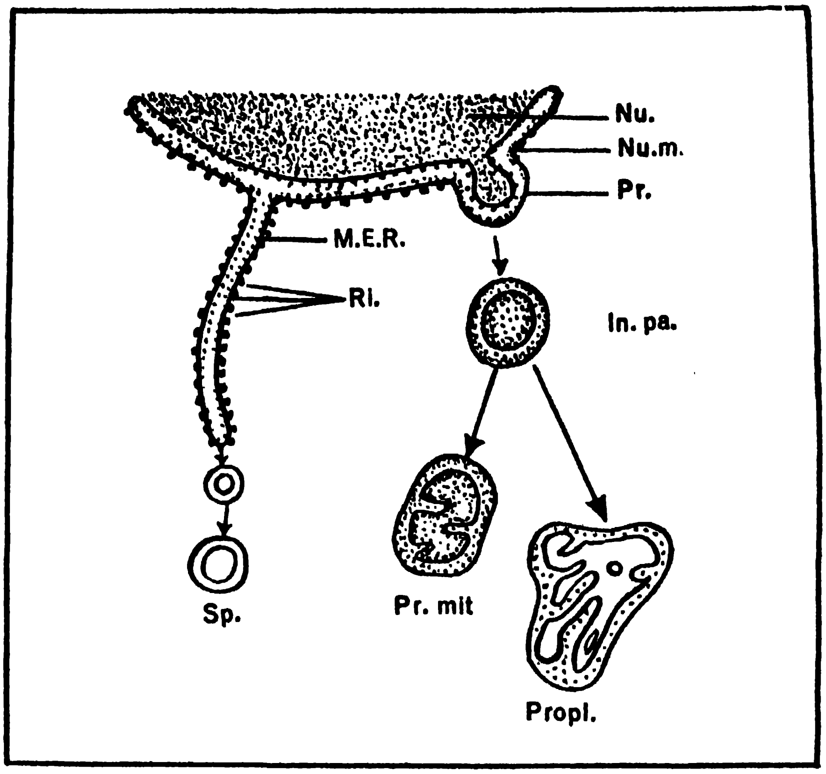


Fig. 1. Origin of cell organelles from nucleus. Nu-Nucleus; Nu.m.-Nuclear membrane; Pr-Protrusion; Pr. mit-Promitochondrion; Propl.-Proplastid; M.E.R.-Membrane of the endoplasmic reticulum; Ri:-Ribosome, and Sp.-Spherosome

Besides, one must understand that the formation of new chloroplasts by division of the pre-existing ones does not tell us whether the genetic information directing the chloroplast development is found in the chloroplasts themselves or whether it comes from the nucleus.

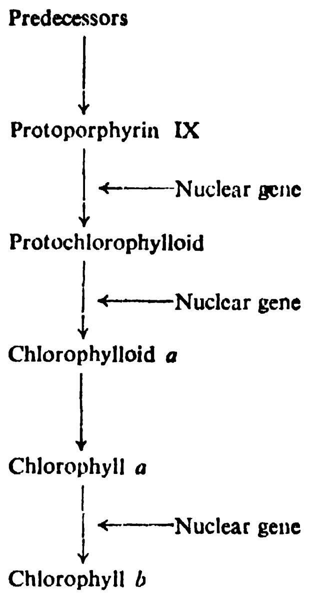
Genetical and biochemical autonomy

Soon after the rediscovery of Mendelism in the beginning of the present century, it was shown simultaneously by German botanists E. Baur in *Pelargonium* and C. Correns in *Mirabilis* that the variegated colour of the leaves in these plants does not mendelize and is inherited always through the maternal side. This was explained by them as a case of cytoplasmic or extra-nuclear inheritance, meaning thereby that the genetic determinants or genes, whose mutations cause specific chloroplast defect, are found in the chloroplasts themselves. Since then a number of cases are known both in plants and animals which show extra-nuclear inheritance.

This hypothesis, first proposed purely on the basis of genetical studies, have been in recent years amply supported by the presence of deoxyribose nucleic acid (DNA) in the chloroplasts of all the species of plants studied so far. Their DNA molecules are circular and confined in the matrix. Besides, they have quite a different sequence of base pairs than the nuclear DNA and are, in all probability, synthesized not in the nucleus but in the chloroplasts themselves. Their quantity is also quite appreciable and usually makes up $2\text{-}10 \times 10^{-15}$ gm DNA for one chloroplast which is sufficient for coding of hundreds or possibly even thousands of protein molecules. Its quantity roughly corresponds to the amount of DNA present in a bacterial cell. O.C. Richards (1967) on the basis of his experiment with *Euglena gracilis* proposed that the DNA molecules of chloroplasts and nuclei may have a number of identical sequence of nucleotides. He concludes that the nuclear genome possesses about 15-17% nucleotide chains of the chloroplast DNA. However, it is too early to conclude like that since not much is known about the mechanism of DNA hybridization.

It has been shown in recent years that the chloroplasts are capable of synthesizing ribose nucleic acid or RNA. The presence of specific RNA molecules in chloroplasts is strongly supported by electronmicroscopic studies demonstrating chloroplast ribosomes (A.J. Jacobson *et al.*, 1963), and by direct isolation of ribosomes from chloroplasts (J.W. Lyttleton, 1962). It has been now fully established that they have their own ribosomes, *t*-RNA and *m*-RNA and the enzymes that activate amino acids. Synthesis of proteins of usual types has been accomplished in isolated chloroplasts of tobacco, beans, *Euglena*, pea, wheat and tomato. They are also capable of synthesizing lipids and fatty acids. It is amply clear now that they possess a significant degree of biochemical independence though some of their *m*-RNA appear to come from the nucleus.

All these evidences suggest that chloroplasts do possess certain degree of genetical autonomy. But to what extent this genetical autonomy holds good? Do the chloroplasts contain all the genetic informations which determine their formation or is part of these informations found in the nucleus? Answers to these questions have been provided in recent years by simultaneous biochemical and genetical studies of a number of mutants with different types of defects in the chloroplast structure. An analysis of mutants that block the chlorophyll formation shows that at least three steps of its biosynthesis are controlled by nuclear genes as shown below:



Similarly it has been shown in a number of plants that inspite of a clear genetical autonomy, some of the steps of biosynthesis of important components in chloroplasts are synthesized definitely by nuclear genes. In the light of our present knowledge it appears that chloroplasts are cytologically continuous, biochemically almost autonomous, and genetically semi-autonomous structures.

NARSINHA DAYAL

Sex determination and abnormalities

IF anything at all appears easy to a lay person, it is determination of sex. No doubt, it is simple in a majority of cases its outward appearances are sometimes deceptive. Morphology could mislead in such cases. A person could be morphologically male and genitically female or vice versa. Again, it is possible by analysis of the blood sample or buccal smear to know the sex of an individual without seeing him or her. Even before the birth of a child, its sex can be predicted with reasonable accuracy.

Human species is characterised by 23 pairs of chromosomes in each cell, of which 22 pairs are called autosomes and one pair is called sex chromosomes (allosomes). There are two sex chromosomes X and Y; Y is smaller than X. If the pair of sex chromosomes is XX in the humans, the offspring is a female; if it is XY, the offspring is a male (however, this is not a rule in all the species, in birds and moths XX pair decides the male and XY the female. In some types of grasshoppers, there is no Y chromosome at all, males have

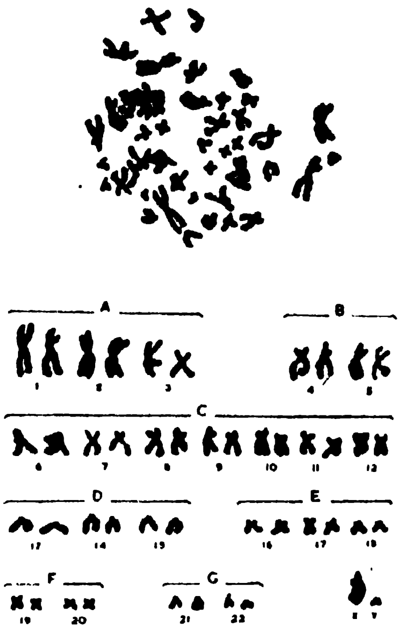


Fig. 1. Karyotype of chromosomes from a normal male (XY) (*Courtesy:* Cytogenetics Laboratory, JIPMER)

one X while females 2X). In any method of sex determination if it is possible to identify the sex chromosomes X or Y, the sex could be determined.

It is interesting to know that we are sexless in the first few weeks after conception, i.e., at the stage of embryonic kidney or mesonephros. In about 5 weeks we enter into the "primitive gonad" stage. The primitive gonad consists of a cortex and a medulla. Now, if the cortex grows at the expense of medulla, one becomes female and if the medulla grows at the expense of cortex, a male comes into existence. The latter process takes place if the primitive gonad possesses XY pair. Thus humans start from sexless state, remain hermaphrodite for some time, and then become males or females. Strangely enough, rudimentary anatomical structures of one sex are present in the other sex. Females possess some male sexual hormones and vice versa.

How is sex determined?

Sex of an individual can be determined by analysing blood, buccal smear, vaginal smear, bone marrow, tissue cells, hair follicle cells, etc. If a blood sample is used, the leucocytes are subjected to tissue culture and chromosomes photographed. Then by the process of karyotyping the chromosomes are arranged into 7 groups and the sex chromosomes identified. If the sex chromosome pair is XX the donor is a female and if XY it is a male (Figs. 1 and 2). By this technique genetic abnormalities due to chromosomal aberrations can also be known, as for example, XXX or XYY conditions.

It is also possible to identify sex by analysis of buccal smear which contains epithelial cells by a technique known as Barr body technique. Female non-dividing (interphase) nuclei contain a characteristically staining piece of nuclear chromosomal material, called the Barr body, representing the contracted state of one of the X chromosomes. The Barr body is situated near the periphery of the cell nucleus. The number of Barr bodies gives the number of X chromosomes minus one, and could be revealed by dyes like toluidine blue. As females have 2X chromosomes, the number of Barr bodies will be (2-1)=1 (chromatin positive). There will not be any Barr body for males (chromatin negative). The Barr body technique can also be applied to hair-follicle cells, vaginal smear, and foetal cells derived from the amniotic fluid (fluid bathing the foetus in the womb). Thus, if on analysis no Barr body is found the individual could be a male, if there is 1 Barr body the person could be a female. Again, genetic abnormalities can also be determined by this technique. If an individual suffers with XXX abnormality there will be 2 Barr bodies.

Y body analysis

Recently a new technique has been developed based on the behaviour of Y chromosome. When the chromosomes were stained with quinacrine mustard and viewed with long wavelength ultraviolet light, L. Zech of the Karolinska Institute, Sweden (1970) noticed that Y chromosome fluoresced more intensely than others. This was confirmed by K.P. George at Guy's Hospital Medical School, London (1971). If quinacrine dihydrochloride is used in place of quinacrine mustard, fluorescent ends of Y chromosome can be seen even in non-dividing cells at a time when the chromosomes themselves cannot be usually seen. As male cells have Y chromosome, the normal male cells display the bright fluorescent spots while the female cells do not do so. Hair-follicle cells are of particular interest since both Barr

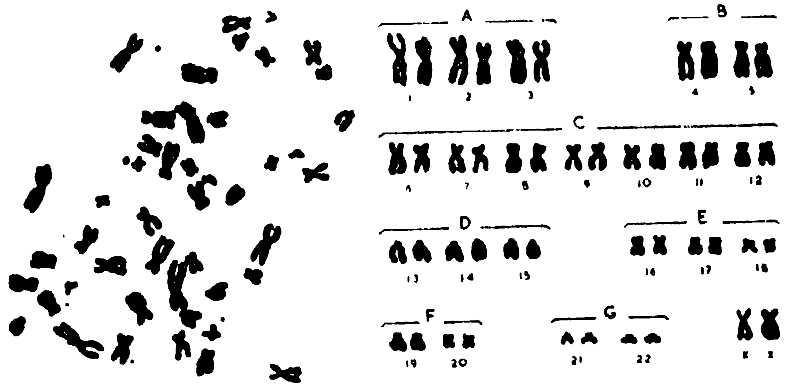


Fig. 2. Karyotype of chromosomes from a normal female ((XX)

and Y bodies can be clearly seen in them as opposed to most tissues in which only the Y body can be visualized. Y body test is applicable to spermatozoa as well. Nearly 50% of ejaculated spermatozoa contain Y body in their nuclei. If the one with Y body is made to fuse with an egg in artificial insemination, a male will be born. However, there are practical difficulties in it. By using Y body analysis chromosome abnormalities related to certain intersex conditions can also be detected. For example, an individual with XYY will have 2 bright fluorescent spots in the cell.

Pre-determination of sex

Both Barr body and Y body techniques can be used for determination of the sex of a child prior to birth. For this, the amniotic fluid containing the foetal cells is taken out from the pregnant mother by amniocentesis. Barr body and Y chromosome analysis could be done on the foetal cells and the sex predicted. Surveys carried out indicate that genetical sex of the foetus can be determined with little error with accurate observation, experience of the observer and quality of the material.

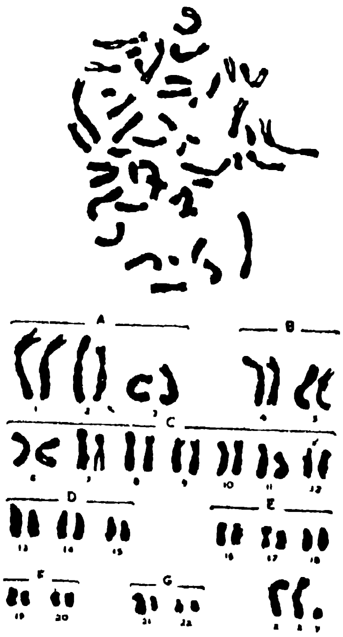


Fig. 3. Karyotype of chromosomes from a patient with Klinefelters syndrome (XXY)

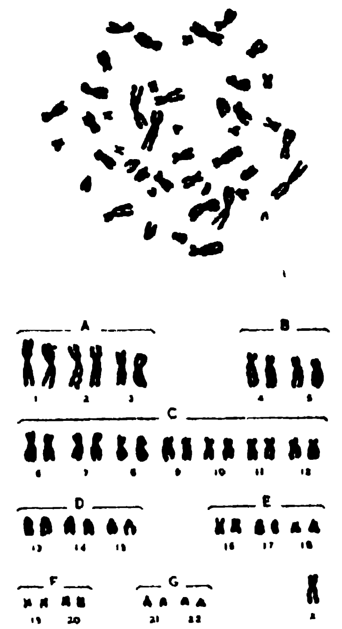


Fig. 4. Karyotype of chromosomes from a patient with Turners syndrome (XO) (*Courtesy:* Cytogenetics Laboratory, JIPMER)

Genetic abnormalities

If XX or XY represents normal sex chromosome pair, what should be the sex in such combinations of chromosomes as XXX, XXY and XYY? In rare instances an egg will have XX instead of the usual X due to absence of separation of sex chromosomes of the cell during meiosis, referred to as "non-disjunction." If this egg with XX fuses with a sperm with X, the offspring (girl) will have XXX. If it fuses with a sperm with Y, the offspring (boy) will have XXY. Such conditions are known as genetic abnormalities. The female with XXX is said to have 'Triple X' syndrome with a total of 47 chromosomes instead of 46 (23 pairs). She could be normal and fertile but in some cases may suffer from mental retardation.

If the chromosomal abnormality is XXY (Fig. 3) the person is said to suffer from Klinefelters syndrome. In this case also there are 47 chromosomes in the cell. The patient is morphologically a male (as he has Y) but genetically a female (as he has 2 X which give chromatin-positive test). As a male he has small testes but is sterile, mentally retarded and gynaecomastic (having abnormally enlarged breasts). Persons having XYY are above six feet tall and extremely aggressive with criminal tendencies.

There is a possibility that sex chromosome pair may have only one X and no other chromosome. This again is due to non-disjunction during meiosis. While the parent egg cell divides into two, its sex chromosomes (XX) do not divide and go with one divided egg cell. The other egg cell is therefore left with no sex chromosome and is designated as O. Fusion of a X sperm with this egg O (containing no sex chromosome) leads to the combination of XO (Fig 4). Persons with XO are said to exhibit Turner's syndrome and have 45 chromosomes. They are morphologically females (as there is no Y) and genetically males (chromatin-negative). Their external genitals are immature and the internal reproductive organs are rudimentary. Such persons are sterile and mentally retarded.

S. RAMAKRISHNAN

Sajina—a source of antibiotic principle

SAJINA (*Moringa petrygosperma*) is one of the plants, which have been widely studied by botanists and pharmacologists. *Sovanjana* or

Akshiva (as it is called in Sanskrit) has been described in the *Shukla Yajurveda* to be 'as mighty as fire' and to give 'vigour and vitality when it gets into the stomach'. It is one of the dicotyledonous angiosperms of the group of flowering plants or spermatophytes (phylum Iignosae, order Capparidales and family *Moringacae*). It has slender drumstick-like fruits, thick bark, pungent smelling root, deciduous tri-pinnate leaves and white, honey-scented flowers. It is cultivated widely in India and grows in the forests of the western Himalayas.

The root has been described as acrid, pungent, stimulant and diuretic, and is applied externally as a rubefacient. Extract of the root has been prescribed in pharyngitis, whooping cough, elephantiasis, dropsy, gout, etc. The seed is said to be stimulant and is given in ascites arising from enlargement of the liver, in splenic disorders, headache, etc. Use of the extracts of Moringa leaves in diabetes and of bark in hepatic and splenic enlargement, dyspepsia, etc., have been suggested. Its latex may be applied locally in headache, boils, etc., or may be used in pyorrhoea. Obviously, our ancestors had done extensive studies on the pharmacological importance of *Moringa pterygosperma.* Recent scientific invstigations have widely supported these findings, particularly those regarding its antibiotic activities.

An active principle named pterygospermin has been obtained from the Moringa plant which shows bactericidal properties. Due to the high antibiotic activity exhibited by the alcoholic extracts of the root as compared with the other parts of the plant, the root is chosen for the isolation of this antibiotic principle. Pterygospermin is an oily substance with a reddish brown colour and a highly pungent smell. It remains active for about two months. It is moderately soluble in alcohol but dissolves sparingly in water and is more stable in acid medium.

Pterygospermin exhibits a very wide range of activity inhibiting the growth of different micro-organisms including the acid-fast and gram-negative ones at fairly high dilutions. It is very powerful in checking the growth of *Mycobacterium tuberculus* (the causative organism of tuberculosis), paratyphoid bacillus (which cause the 'C' type of paratyphoid fever), *Staphylococcus aureus,* dysentery bacillus, etc., in a culture medium. It should be noted here that in the *Ayurveda* the extract of Moringa root has been prescribed in abscesses, pyorrhoea, etc., which are caused by *Staphylococcus aureus,* one of the organisms inhibited by pterygospermin.

The antibiotic activity of pterygospermin is very stable. A number of antibiotic substances are inactivated by cysteine and other similar compounds containing reactive sulphhydryl groups, but pterygospermin is not inactivated by sulphhydryl reagents. It has also been observed that in the presence of nucleic acids which normally antagonise antibacterial activity, the activity of pterygospermin remains unimpaired.

The antibacterial activity of pterygospermin against a wide range of pathogens suggests the possibility of its therapeutic applicability in human infections. However, such a possibility can be entertained only if investigations on its toxicity prove it safe for human use.

BHABANI PRASAD SAHOO

Synthesis of chlorophyll in dark

NORMALLY light is required for the synthesis of chlorophyll in plants. There are two light-mediated steps known today in the biosynthetic pathway of chlorophyll formation (Fig. 1). The requirement of light for the synthesis of δ-aminolevulinic acid (first light mediated step) is not yet well established, but the conversion of protochlorophyllide to chlorophyllide-*a* (second light-mediated step) is no doubt light-mediated. Although the light requirement for the conversion of protochlorophyllide to chlorophyllide-*a* appears to be absolute in angiosperms, in some gymnosperms, and some ferns, in many algae chlorophyll can be synthesized completely in the dark solely through the enzymatic activity.

As early as 1859, chlorophyll was observed by Sachs to occur in the cotyledons of coniferous seedlings grown in darkness. E.G. Sudyina studied in 1963 the dark synthesis of chlorophyll in gymnosperms like Scotch pine (*Pinus silvestris*), spruce (*Picea excelsa*) and Siberian larch (*Larix sibirica*). In dark-grown seedlings both protochlorophyllide and chlorophyllide were present, while in light-grown seedlings only chlorophyllide was found. She suggested that the biosyntheitc pathway for chlorophyll synthesis is the same in the dark as in the light. However, some workers have suggested that the formation of δ-aminolevulinic acid is light mediated. If this is true, then a difference between dark chlorophyll synthesis and light mediated chlorophyll synthesis can be found at this step of the biosynthetic pathway.

M. Bogdanovic of the Institute for

the Application of Nuclear Energy in Agriculture, Yugoslavia contributed a lot to the understanding of the synthesis of chlorophyll in dark. In 1972 he, with his coworker D. Nicolic, showed that in the cotyledons of black pine (*Pinus nigra*) intensive chlorophyll synthesis in dark is accompanied by grana formation in a similar way as it happens in angiosperms during greening. He noted the following parallelism.

(1) In black pine seedlings a very slight increase in the total chlorophyll was noticed between 2 to 5 days, followed by rapid chlorophyll synthesis. The slight increase in chlorophyll content between 2 and 5 days corresponds to the lag phase of chlorophyll synthesis during the greening of angiosperms, which lasts from 1 to 3 hours. Since chlorophyll synthesis in angiosperms is controlled by light, it is faster than chlorophyll synthesis in dark in gymnosperm cotyledon. The latter is however, a purely enzymatic process.

(2) In black pine seedlings the chlorophyll content reaches a maximum within 15 days, then it decreases gradually. Senescence first becomes visible externally as yellowing of the cotyledon tips begin on 19th day. Similar results are shown by cotyledons of squash and cucumber while greening in the light.

(3) In black pine seedlings the chlorophyll *a*/*b* ratio decreases from 10 from 2nd to 3rd day after 5 days and remains constant. After this constant ratio has been reached faster chlorophyll synthesis occurs. Same is observed in angiosperms.

These results therefore show that the chlorophyll synthesis in the dark in gymnosperm cotyledons proceeds in the same way as in the light in etiolated leaves of angiosperms. However, they are regulated by two different mechanisms.

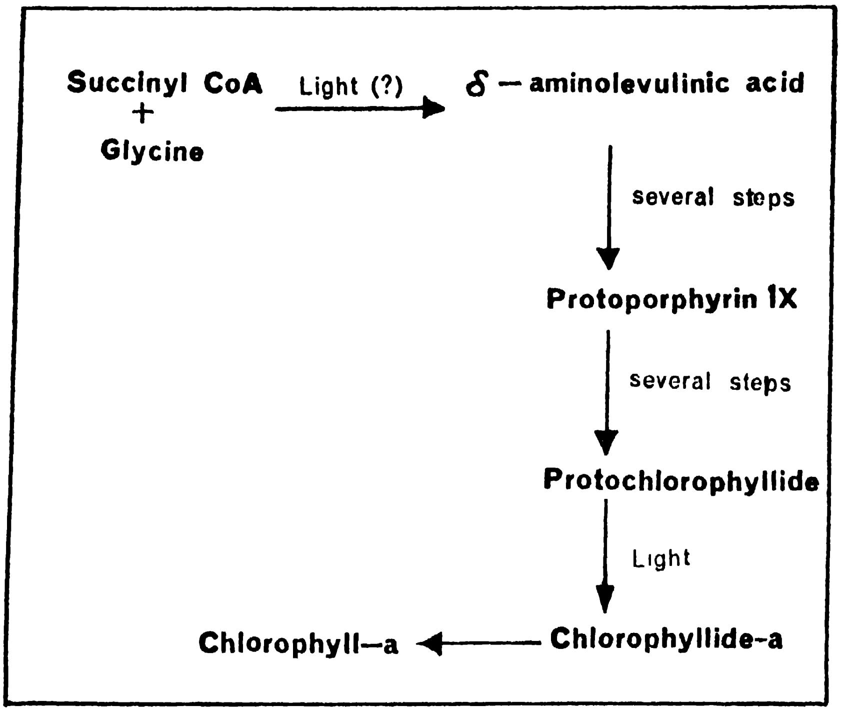


Fig. 1. Pathway of chlorophyll biosynthesis in angiosperms

Bogdanovic also observed in transplantation experiments that a substance present in megagametophyte of black pine induced the formation of chlorophyll in etiolated wheat (*Triticum vulgare*) leaves in dark. He transplanted primary wheat leaves from the embryo on to the black pine megagametophytes and grew them in the dark. Presence of chlorophyll in these transplanted, dark-grown wheat leaves was observed. Some unknown factor in the black pine was perhaps able to synthesize chlorophyll in wheat leaves, grown in dark from protochlorophyllide. Thus photostimulus required for chlorophyll synthesis in angiosperm seedlings is substituted by the activity of an unknown factor present in megagametophyte of gymnosperms.

Some workers have, however, observed traces of chlorophyll in angiosperms completely grown in dark. It is assumed that in angiospermous plants, side by side with a photochemical system for normal chlorophyll synthesis, a purely enzymatic system also exists which is capable of acting in the dark. In the course of evolution this phyllogenetically older system has degenerated in varying degrees, but in some cases it still exists.

MANORANJAN KAR

Oil pollution in the sea

IN recent years pollution of the environment has become an important topic for national and international consideration. Because of its impact on society pollution has attracted the attention of scientists and, seeing the present calamity, even of the common man.

Pollution can be defined as any substance added to the environment as a result of men's activities which has a measurable and generally detrimental effect upon the environment. In a more restricted sense the term pollution is used mainly when the changes are harmful or in conflict with other uses of the environment. Marine pollution is defined as discharge of waste substances into the sea resulting harm to living resources, hazards to human health, hindrance to fishery and impairment of quality for use of sea water. Marine pollution is associated with the changes in the physical,chemical and biological conditions of the sea waters.

In the marine environment oil pollution appears to be the main problem and it is a threat to the marine ecosystem and to the fisheries of the world. Oil pollution of harbours, bays, beaches and the open ocean has been increasing day by day.

The main oil products discharged into the marine environment from the shipping operations both on the high seas and at the coastal belt are the light diesel oil, high-speed diesel and crude petroleum. Such extensive spreading of oil affects the floating plantation and also the marine life along the beaches. In areas of oil exploration, fishing gear and craft operations are also affected by crude oil and lumps of oily tar. The fish catches have to be discarded because of tainting. Wastes from oil refineries and discharged petroleum from ships also cause heavy damage to fishery.

Oil pollution comes from many sources; oily wastes from oilfields or refineries near the coast produce local problems in these areas. Some of it comes from oil tankers, ships and offshore oil wells.

The dispersion of oil and its persistance in the sea are affected by a number of factors—the kind of oil, its specific gravity, chemical composition and the state in which it is discharged into the sea. Water currents and temperature are also important in determining the location and duration of oil slicks in the sea water.

Two of the most publicised oil spills in recent years were the wreck of the tanker 'Torrey Canyon' (1967) which caused damage to English and French coasts and the blow out of an oil well at Santa Barbara California in the USA. Both of these disasters occurred offshore in relatively deep waters, but caused extensive destruction of coastal marine fauna. However, it was impossible to distinguish between the effects of the oil itself and of the detergents and dispersants used in an effort to control the oil pollution. On 18th June 1973, *M. V. Cosmos Pioneer* broke into two near Porbandar due to rough weather releasing 18,000 tons of light diesel oil. It caused considerable harm to the pelagic fisheries of the Gujarat coast.

The harbours and beaches of both west and east coasts of India are polluted to some degree with various kinds of oily and tarry substances. Occurrence of tar-like lumps were noticed and reported by Dr. N.K. Panikkar (1970) in the Goa beaches. Owing to the importance of beaches and visible danger of pollution, extensive studies of this material in the various beaches of India are being carried out by the National Institute of Oceanography. In the mean time the Central Marine Fisheries Research Institute is also investigating the aspects of marine pollution and its effects on fisheries. Recently heaps of dead fish were washed ashore between Dabolim and Velcao coast in Goa. It created a big scare among the local people, especially the fishermen. It was believed that the mortality of fish was due to dangerous effluent discharge from the Zuari Agro-Chemical Fertiliser Factory. Large scale fish kills have also been reported by B.F. Chapgar (1971) near the Bombay coast. A knowledge of the distribution of the oil and the location of its concentration is necessary before effective measures can be taken to confine, control and clean up the oil slicks. Reliable information on the thickness of oil film is required to estimate the volume of slick essential for an assessment of its impact on marine life and environment. Experiments conducted in the east coast of USA by Drs. J.P. Hollinger and R.A. Mennella (1974) have shown that microwave radiometry offers a means of measuring the distribution of oil on the sea surface and of measuring their volumes on an allweather day-and-night basis.

Accidental discharge of oil can be cleaned up by several methods. But, as with all pollutents, the only effective measure for controlling contamination by oil of the aquatic environment is the prevention of avoidable spills and releases. Among the oil removal methods in use today, mechanical containment and removal of oil appear ideal from the point of view of avoiding long term biological damage.

P. NAMMALWAR

NEWS & NOTES

1974 Nobel Prizes for Physics, Chemistry and Medicine

Physics

The 1974 Nobel Prize for Fhysics has been awarded jointly to Dr. Martin Ryle and Dr. Antony Hewish, both Professors at the Cavendish Laboratory of the Cambridge University, England. Dr. Ryle was cited for his work in developing advanced techniques for using telescopes in observing details in celestial bodies and Dr. Hewish for his part in the discovery of mysterious energy sources called pulsars. Dr. Ryle used the techniques known as aperture synthesis to gain much new information about the nature of various objects in the universe and proposed the 'big bang theory' that the universe was created by an explosion and is still expanding (in contrast to Dr. Fred Hoyle's theory that the universe exists by the continuous creation of new matter, replacing old matter). It appears that Dr. Ryle's theory is getting much support among radioastronomers now. Dr. Hewish's major achievement is the discovery in 1967, using radiotelescopes, of pulsars, the objects far out in the space that regularly emit pulses of radiowaves, generally at intervals of one-half to two seconds. Because most radioastronomers used to examine the sky with devices that took, in effect, time exposures, they failed to observe any phenomenon that took less than several hours to occur. Dr. Hewish, while studying the rapid variations of distant radio signals, had been using equipment capable of shorter exposures; one of his students, Jocelyn S. Bell, noticed that in certain parts of the sky objects were sending out extremely regular pulses of radiowaves. Further studies found pulsars in other parts of the sky and Dr. Hewish interpreted that the signals were coming from relatively small celestial objects that were spinning. A spinning source of radiowaves is believed to give the impression, when viewed from one point, of turning off and on repeatedly. The award of the Physics Nobel Prize to Drs. Ryle and Hewish marked the first recognition by the Nobel Award Committee of achievements in radioastronomy.

Born on September 27, 1918 young Ryle received his education in Oxford, and after World War II, joined the Cavendish Laboratory at Cambridge. He became a Fellow of the Royal Society in 1952, and in 1959 he was appointed to the first Chair in radioastrophysics at Cambridge University, where he has been for almost 30 years. He was knighted in 1966 and in 1971 he was named Astronomer Royal of Britain.

Born in Britain on May 11, 1924, young Hewish was educated at Cambridge University. After World War II, he returned to Cambridge University and joined the research group of Dr. Ryle. He spent a year at Yale University as a visiting professor. A Fellow of the Royal Society, Dr. Hewish has been a Professor of radioastronomy at Cavendish Laboratory since 1971.

Chemistry

Dr. Paul John Flory, 64, Jackson Wood Professor of Chemistry and Chairman of the department of research at Stanford University, California has been awarded the 1974 Nobel Prize in Chemistry in recognition of his outstanding contributions in developing analytical methods now used by polymer chemists all over the world to study and compare properties and molecular architecture of high polymers. Prior to Dr. Flory's development of analytical methods, there was no reliable way to study many different kinds of polymers in various states or to determine their usefulness for various applications. When any polymer is heated to a certain temperature, it exists in an ideal state that can be studied to reveal its properties. This temperature is known as "theta temperature" or "Flory temperature". When any polymer is studied at its theta temperature, the measurements of its properties can be compared to those of different polymers. Dr. Flory also discovered a number of basic properties of polymers such as the conditions under which they increase the length of the polymer molecules. He also discovered the phenomenon how one molecule that is growing can transmit its growing power to another molecule and cease growing itself. Dr. Flory's research began as a member of the team at the Du Pont Experimental Station at Wilmington, Delaware that first synthesized and commercially exploited nylon—the earliest polymer to receive wide applications. Although his subsequent studies did not concentrate on any one synthetic polymer, his findings enabled researchers to develop thousands of new polymers used later in clothing, tires, paints, films, toys, lubricants, machine parts and scores of other products.

Born on June 19, 1910 in Sterling, Illinois, young Flory studied at Ohio State University at Columbus, where he received his Ph.D. degree in 1934. At Du Pont Experimental Station he worked with Dr. Wallace A. Carothers who developed nylon. Later he worked at Standard Oil Development Company in Elizabeth, N.J., at Goodyear Tire & Rubber Company in Akron, Ohio; at Cornell University (Professor of Chemistry) and Melon Institute in Pittsburgh (Head of the research section). Awardee of the American Chemical Society's Priestley Award (1974), Dr. Flory authored the classical textbook of polymer chemistry *Principles of Polymer Chemistry*.

Medicine

The 1974 Nobel Prize for Medicine or Physiology has been awarded jointly to Dr. Albert Claude, Director of Jules Bordet Institute in Brussels, Dr. George Emil Palade, Professor of Cell Biology, Yale University School of Medicine, New Haven, and Dr. Christian de Duve, Professor of Cell Biology at Rockefeller University in New York and at the University of Louvain in Belgium, for their innovations that started the modern science of cell biology nearly 30 years ago and for their major contributions to the understanding of the inner working of living cell. Dr. Claude was the first to use electron microscope to study cells and pioneered in the use of centrifuge in separating different components of a cell. Dr. Palade and Dr. de Duve improved these techniques to define and analyse functions of components of cells, such as mitochondria, microsomes, ribosomes, lysosomes and peroxisomes. As a result of their and others' studies, cells are known to have a variety of specialized internal organs or organelles which are able to digest nutrients from outside, repair their internal damage, synthesize cell materials, regulate their metabolism and destroy invading germs. Research is now under way to find selective means to treat diseases that may arise from problems of one or other type of organelle. In 1970, the Columbia University's prestigious $25,000 Louisa Gross Horwitz Prize was awarded to Dr. Palade, Dr. Claude and Dr. Keith R. Porter for their contributions to the knowledge of the function and fine structure of cellular materials (*Science Reporter*, 8, 231, 1971).

Born in August, 1899 in Luxembourg, young Claude joined to schools in Belgium. In 1929, when he just completed his medical education at the University of Liege, he received a Government scholarship for overseas study to come to New York's Rockefeller University. He was associated for 20 years with this University where using the first electron microscope available in New York, he made the first successful application of that equipment to the study of cells and then developed centrifugation to separate cell components. In 1950, Dr. Claude returned to Belgium and for the next 20 years built a cancer research centre at the University of Belgium. He retired from there a few years ago and now heads Jules Bordet Institute in Brussels.

Born on November 19, 1912 in Jassi, Rumania, young Palade had his medical degree in Bucharest (1940) and taught Anatomy at Bucharest Medical School. In 1946 he came to Rockefeller University as a visiting investigator to work with Dr. Claude. There he became later Assistant Professor, Associate Professor, Member and Professor of Cytology, and Professor of Cell Biology. In 1972, Dr. Palade left Rockefeller University to take over the Cell Biology Department of Yale University School of Medicine, New Haven. He is much renowned for his outstanding contributions in the elucidation of fine structures of cellular components including ribosomes which are also known as Palade granules.

Born on October 2, 1917 in England, young de Duve had his medical degree from the University of Louvain in 1941. He also received master's degree in chemistry in 1946. He then left Belgium and worked in the Nobel Institute in Stokholm and at the Carl Cori Institute of Washington University at St. Louis before returning to the University of Louvain. In 1962, Dr. de Duve accepted an appointment to work part-time at Rockefeller University in New York. Honoured by a number of universities in Europe and U.S.A., he authored a book entitled *Glucose and Insulin in Diabetes* (Paris, 1945). Besides his developing methods for fractionation of cells and discovery of lysosomes and peroxisomes and their enzymatic profiles, Dr. de Duve carried out major research on carbohydrate metabolism regarding action of insulin and glucagon in diabetes.

R.K. DATTA
BHAKTI DATTA

CORRIGENDUM

Ref. *S.R.*, Sept-Oct. 74, Metric units through the ages, on page 455, col. 2 line 4, *read* $513\frac{17}{62}$ *for* 513 62/17 and in para 2, line 1, *read* $1/12.96 \times 10^6$ *for* $1/12.9^6 \times 106$

MEDICAL NOTES

Cyanate therapy of sickle cell anemia

SICKLE cell anemia is a hereditary disease found predominantly in the black population of the world. It is estimated, for example, that 10% of the black population in the United States carries the gene for the disease. The incidence for the gene is even higher in parts of Africa where upto 46% of the population has been estimated to carry the gene. This disorder is characterized by the fact that the red blood cells (RBC) of the affected individuals change their normal shape (biconcave disk) to a sickle or crescent shape when the oxyhemoglobin is reduced to hemoglobin as a result of exposure to reduced oxygen tension. Sickling occurs in the capillaries as the hemoglobin is reduced, and about 85% of the hemoglobin crystallizes from the solution within the red blood cells thereby distorting the cell. The sickled cells exhibit markedly increased fragility and tend to hemolyze in small diameter of the capillary leading to reduced number of erythrocytes (RBC); hence the term sickle cell anemia. This abonormal hemoglobin, designated as sickle cell hemoglobin or Hb S, differs from the normal hemoglobin in that a valine residue replaces the glutamic acid residue at position 6 of the beta chain.

This substitution of a hydrophobic amino acid, valine, for a hydrophilic amino acid led to the postulation that hydrophobic bonds were important in the reversible gelling of hemoglobin S (*Science*, **153**, *145*, *1966*). Disruption of the hydrophobic bonds by ingestion of large amount of urea into the patients with sickle cell anemia led to some hopeful results. Although urea is a well-known protein denaturant whose concentrations of 1-8 mols are usually required to disrupt hydrophobic bonds in most proteins. Moreover, it seemed unlikely that such levels would be maintained in patients since urea is rapidly cleared by the kidneys. Therefore, clinical improvements of several patients by urea therapy could not be successfully explained by the phenomenon of interruption of hydrophobic bonds *in vivo*.

It was known from some time past that urea in solution exists in equilibrium with cyanate which can react with the functional group of proteins. Hence the role played by cyanate in reversing back the gell-like aggregates of hemoglobin S needed a careful analysis. Dr. James M. Manning and his group at the Rockefeller University, U.S.A. took up the investigation regarding the possible use of cyanate as a therapeutic agent in the treatment of sickle cell anemia (*Proc. Natl. Acad. Sci.*, U.S., **68**, *1180*, *1971*). When red blood cells from the patients with sickle cell disease were incubated with either potassium or sodium cyanate and then deoxygenated, the cells no longer underwent a change in morphology. It was also found that the incorporation of C^{14}-cyanate into the acid-precipitable protein could be directly correlated with the inhibition of sickling. After finding that cyanate inhibited the sickling process, attention was further focused on the site of action on the red blood cell.

Chemical analysis of the C^{14}-cyanate incorporated into the acid-precipitable protein revealed that C^{14}-cyanate specifically carbamylates with NH_2 terminal valine of the hemoglobin molecule. Since both the alpha and beta chains of the hemoglobin molecule have NH_2 terminal valines, the extent of carbamylation was also found to be the same for both the chains. Dr. J.M. Manning and his group believed that cyanate is specific for the NH_2 terminal valine of the hemoglobin molecule.

Carbon dioxide reacts with the NH_2-terminal valine of the hemoglobin molecule to form a carbamino group. It is estimated that approximately 30% of the expired carbon dioxide is carried from the tissue to the lungs via these carbamino groups. Isocyanic acid which is the reactive species of the cyanate group reacts with the same amino terminal valine of the hemoglobin molecule, but in contrast to carbamino formation the carbamylation reaction is irreversible.

Recently, Manning and his group (*J. Biol. Chem.*, **248**, 8052,1973) have reported the distribution of carbamyl groups on the hemoglobin chains prepared from the blood of patients on oral cyanate therapy which suggests that carbamylation *in vivo* takes place predominantly with the deoxygenated hemoglobin. From the studies on the distribution of radioactive cyanate in different organs it was observed that the uptake is maximum in the hemoglobin molecule, followed by muscle and bone. It was also found that the level of carbamylation was quite low in other organs.

Before beginning the clinical evaluation of the use of cyanate in the treatment of sickle cell diseases, a series of toxicological experiments were initiated to ascertain the effect of cyanate on experimental animals.

(Continued on page 508)

SCIENCE FOR THE YOUNG

Porpoises—Fascinating sea animals

PORPOISE is a general term often applied to any of the smaller round-muzzled toothed whales, but technically only family *Phocaenidae* is known for porpoises. These, along with whales and dolphins, are included in the mammalian order Cetacea. There is no sharp difference between porpoises and dolphins. The genus *Phocaena* includes the common porpoises. They are characterised by a torpedo-shaped fishlike body; anterior limb (flippers) that are paddle-shaped and movable to varying degree according to species; no external digits or claws; no external hind limbs; the tail flattened laterally and bearing horizontal flukes at the tip in all living species. Body essentially is hairless, has no sweet glands and possesses a thick subcutanious layer of blubber. Only internal vestiges of the ear pinna are present; the bones of the skull are strongly telescoped; the external nares (blow hole) are usually on the top of the head and the rostrum is greatly elongated, sometimes into an obvious beak or snout.There is also a single dorsal fin.

Relatively little is known about the biology of wild porpoises. It is an exciting field of study for the biologists. They are mostly studied in captivity and observations are made for behavior, social structure, activity and vocalization.

Porpoises are exclusively aquatic animals. They are usually found near the coast line in tropical and temperate marine waters, both mainland and insular. They are frequently found in harbours and estuaries and venture often into pure freshwater for apparently short periods. Some species of porpoises travel in thousands. Some are exclusively pelagic while others live permanently in Arctic and Antarctic seas.

Like most other mammals these superficially fishlike forms breathe air directly for which they come regularly to the surface. Porpoises feed on schooling fish, such as herring and mackerel as well as on squids and other marine animals. Their wide mouth is provided with teeth numbering 80 to 100. They become sexually mature at about six years of age and the gestation period is about one year. The adult porpoises mate in late summer and the female gives birth to a single calf, about a metre long, in an year or so. Our knowledge is very limited about the life span of porpoises. However, age at maturity, gestation period and life span of different species are not similar.

Probably the best known of the porpoises, is the bottle-nosed dolphin, *Tursiops truncatus*. This is the animal which is popular to such a high degree on television, in the popular press and as a highly-trained show-animal in public and private aquarium and oceanarium. In size this species usually ranges up to 2½ metres in captivity and as free they are known to reach some 3½ metres in length. There is also some geographical variation in colour pattern. Wild Tursiops usually travel in schools varying from three or four to hundreds of animals.

In recent years attention has been drawn to the behavior of porpoises. The use of sound by porpoises for echolocation and intraspecific transfer of information has been observed. They also produce supersonic pulse. Because of their intelligence and ability to communicate with one another, they have become the object of serious scientific experimentation in recent years. There is no evidence that they have a language in the sense of a human language. However, it appears from the experiments that they do express emotions by use of

(*Continued on page* 488)

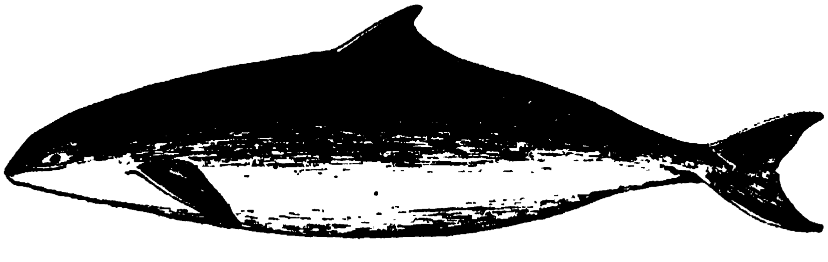


Fig. 1. A common porpoise

SCIENCE IN INDUSTRY

Mechanised casting of cored/hollow concrete units

FLOORING the roof of a building is a major item and accounts for about 25% of the building cost. Any saving in this item alone will go a long way in reducing the total cost of construction. Precast hollow/cored concrete units lead to savings in the consumption of materials such as concrete and steel and thus have been accepted as an economic substitute to the traditional *in situ* solid slab construction. Because of their hollow structure, the units are much reduced in weight. This makes their handling easier, and further reduces the dead load on bearing walls, resulting in economy in the foundations as well. These savings can be realized to a greater degree when the cost of producing the hollows is kept as low as possible, ensuring at the same time a consistently better quality. The production scheme should also be flexible enough to be adopted for producing reinforced as well as prestressed units.

In industrially advanced countries the production of cored/hollow units is mainly being done in highly mechanized factories, wherein the plants work either with extrusion or multilayer compaction machines. Some of the east European countries utilize individual mould pressure vibration technique for the same purpose. In all these cases, highly sophisticated machines are used for the preparation and feeding of concrete alongwith accelerated curing methods, such as steam-curing.

In India, the infrastructure of the building and allied industries is not in a position to adopt such a technique and the plants involved in their present form. The technique to be adopted and the plant involved have to be simple, requiring low capital and should be labour-intensive, so as to be readily acceptable.

The Central Building Research Institute, Roorkee has developed a process as well as a plant based on pressure vibration technique for mechanized casting of cored/hollow concrete units.

The mould alongwith the reinforcement cage is placed on the casting platform and the cores, mounted on a trolley, are introduced into it. An initial charge of concrete is poured into the mould and the cores are vibrated, thus making the concrete to flow around the pipes to the soffit of the unit. An additional charge of concrete is then added and a dead weight is placed on it to act as pressure on the concrete. Immediately after the vibration is stopped the cores are withdrawn and, after the removal of the dead weight, are cured.

The equipment required for making the cored/hollow units are: casting set-up including the vibrating assembly; pulling winch and fixed gantry mounted with hoists; transferring trolleys; mixer; gantry for unloading; and moulds. All the equipment are indigenously available.

A pilot plant having a production capacity of 35 to 40 units per shift is working at the institute. This can be demonstrated to the parties interested. The prototype has been tested in extensive field trials and the plant is now being accepted by various Public Works Departments.

The raw materials like cement, sand, stone, cast iron, mild steel sheet and structures required are available indigenously.

The estimated capital investment for the production of 35 units of size 30×360×13 cm per day on the basis of a single shift working per day for 300 days' working in a year is about Rs. 1.91 lakh when they are produced in a factory, and Rs. 1.21 lakh when produced at site.

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BOOK REVIEWS

BLACK HOLES: THE END OF THE UNIVERSE by John Taylor, *Souvenir Press Ltd.*, 95, Mortimer Street, London W 1 N 8 HP, Pp. 175, £ 2.50.

BEGINNING with man's inquest into the composition of the heavens—the Sun, the stars and other objects, astronomers today have been able to amass a large amount of information on various aspects of their formation, existence and decay. One of the exotic subjects in astrophysics which is being vigorously studied is about quasi-stellar sources and gravitational collapse. The most complete theoretical treatment has been developed in case of stellar collapse accompanied by a supernova explosion. It presents deep and fascinating problems which lie between elementary particle physics and quantized geometrodynamics. These are discussed extensively in the set of two volumes, *Gravitation Theory and Gravitational Collapse* by B. Kent Harrison and others, and *Quasi-Stellar Sources, and Gravitational Collapse* edited by I. Robinson and others (both Univ. of Chicago Press), none of which are unfortuately referred to in the Bibliography at the end of the book. While these volumes contain sophisticated discussions in astrophysical parlance, the presentation by Prof. John Taylor in this book under review gives a very readable account of the ghastly phenomena of 'black holes.' These are formed by the collapse of a heavy star to such a condensed state that nothing—*not even light*—can escape from its surface. When a star has consumed its nuclear fuel, the core temperature falls, thermal and radiation pressures can no longer balance the pull of gravity and the star collapses. When the collapsing star comprises 3 solar masses (a solar mass$=2\times10^{33}$g), no known physical force can resist its collapse to infinite density. In less than a millisecond the star gets completely crushed by its own gravitational field and all that remains is a black hole of space in which gravity traps all radiation. The boundary of the black hole is called "event horizon"; this is the trapped region where anything happening inside cannot be communicated to the outside. Einstein's general theory of relativity, if accepted and found correct, inevitably leads to the conclusion that massive stars must one day evolve into black holes.

What happens to an observer inside the black hole? Like science fiction, the author uses his facile pen to describe the outcome of such events. If an unlucky astronaut approached a black hole his eyes would be blinded by cosmic ray flashes. He would be fried by X-rays and so would be his spacecraft, torn and crushed by tidal forces. The author gives a fascinating picture of the distortion of time effect and its relation to black holes, and indicates the possibility of their existence in other galaxies from evidence gathered from the X-ray star Cygnus X which is about 6000 light years (1 light year$=9.46\times10^{12}$ km) from us, and Scorpio X. Dr. Herbert Friedman of the U.S. Naval Research Lab and Vice President of COSPAR, widely regarded as the dean of rocket astronomy, writing in *Astronautics and Aeronautics* April 1974 issue under 'Exotic Astrophysics' has said that it appears inevitable that massive stars will evolve into black holes and that their evolution has already begun. Late in December 1974 the Crab nebula will be occulted by the Moon. This will permit once again, with more sensitive equipment, to repeat the X-ray rocket observations about spectral and spatial measurements. If the neutron star, pulsar, is hotter than 1.5 million degrees, it will be possible to observe its steady thermal black-body emission apart from pulsed X-rays. Since the distance of Crab is known, the black body flux would yield a measure of the size of the neutron star. If the measurement should give a radius of about 10 km, confidence in the theory of condensed stars will be greatly strengthened and the evolution of black holes becomes a reality.

Dr. Taylor, apart from describing the cannibal type swallowing effects, also discusses how black holes could be tamed and their massive energy used by mankind. The reading here is fascinating but in the opinion of the reviewer is technologically not feasible atleast with the existing knowledge at mankind's command. Within the black hole it is not possible to state with any certainty what would happen and the author does admit this although he ventures to suggest boldly what can be expected. When the time comes and our earth is trapped in such black holes the entire living species may be annihilated, once we fall in this highly condensed matter. In this dreadful thought, well explained by the author, the reader may get some solace in the last chapter in which the happenings in the physical world are interrelated with the basic human beliefs and tenets of survival, immortality, and reincarnation. The author should have indicated other popular speculations about black holes for today nearly all baffling phenomena in contemporary astrophysics and cosmology are temptingly tried to be explained by black holes, big or small. Among these are cosmic-ray air showers, gamma-ray bursts, the solar neutrino deficit, the binding of hardons in the atomic nuclei and even the power of Big Bang itself. Except for the first three chapters, which are a little boring the remaining nine are highly interesting and intriguing presenting, as they do, a survey of this doomsday weapon which mankind has to face once. There is a good bibliography and a subject-author index for those who wish to dwell deeper into the astromysteries of the black hole.

S.K. GHASWALA

MUSHROOM HANDBOOK by Louis C.C. Krieger, *Dover Publications Inc.*, New York, 1967, Pp. I—VII+560, $ 3.95.

THE book was originally published by the University of the State of New York in 1935. The Dover Edition incorporates a new preface and appendix and was first published in 1967.

Mushrooms are fungi belonging to the plant kingdom where the chlorophyll is absent. This book enlists and describes all the mushrooms that are either edible or deadly poisonous. The author has freely consulted the writings of professional mycologists for descriptions of the species. The excellent coloured plates of some of the mushroom species have been drawn by the author himself.

The book gives a very clear description of the field study of mushrooms and other fungi. There is a ready key to the mushroom family based on their onservable characters. Conditions under which mushrooms can grow and thrive have been very clearly described. The chapter on how to collect, study and prepare mushrooms for the herbarium will be very helpful to students of botany. Another chapter on the life history and general characteristics of mushrooms will also be very useful to students where the life history of mushrooms with special reference to reproduction, spore dissemination, growth, size, colour, surface texture, odors, taste, exudations bioluminescence, etc., have been described. In the chapter on economic importance of fungi, mention is made of edible and poisonous species and the importance of moulds helpful to the industries for the production of alcohol, cheese, leather tanning, etc., has been discussed. Emphasis is also laid on the fact that moulds are also destructive to economic plants when they attack and infect woody plants or crop plants like wheat. Description of common edible mushrooms is nicely dealt, with the help of which even a layman would be able to collect mushroom for his kitchen. There also appears a number of recipes for cooking mushrooms. A portion of the book has been dedicated to the methodology concerned with the growing of mushrooms. A systematic account of selected larger fungi to which the mushrooms belong, with a key to the classes, orders, families and genera have also been given. There is an excellent bibliography and a glossary of technical terms. Nomenclature changes which occur for various reasons have been compiled by Robert L. Shaffer at the end of the book. Chapters are not numbered and the book is a continuous one, of course, with different headings and sub-headings which give effect of chapters. This book has been serving a purpose for a longtime and will do so for many days to come. It will find use both with the amateur and professionals alike.

AJIT K. MISHRA

CYANATE THERAPY (*Continued from page 504*)

The L.D.$_{50}$ (lethal dose) for a single injection of sodium cyanate in mice, rats and dogs is approximately 250-275 μg/kg. Such carbamylation by cyanate was, however, not found to be detrimental to the overall metabolism of the red cell. Also no abnormalities were found from the toxicological tests. However, one side effect of cyanate therapy does happen. The reproductive capacity of the mice was found inhibited as long as they were maintained on a 1% cyanate diet. When the animals were put back to a regular diet, the reproductive capacity was regained and the animals had normal pregnancies.

The object of these chemical and biological studies was to determine whether cyanate can be administered safely to patients. with sickle cell disease. Dr. Peter Gillette of the Rockefeller University Hospital, U.S.A. began a clinical evaluation of cyanate. The results were encouraging and he was able to obtain the necessary further approval from the Food and Drug Administration and the Hospital Committee to use cyanate by oral and intravenous routes.

Although short time side-effects of cyanate therapy are almost nil, nothing has yet been said about the long term side-effects. It is quite obvious that cyanate is still an experimental drug at an early stage of development and much work is needed to establish its safety and potential clinical usefulness. It is hoped that cyanate will serve as an example of a new class of drugs designed to chemically modify the abnormal proteins of genetic diseases so that they can function normally.

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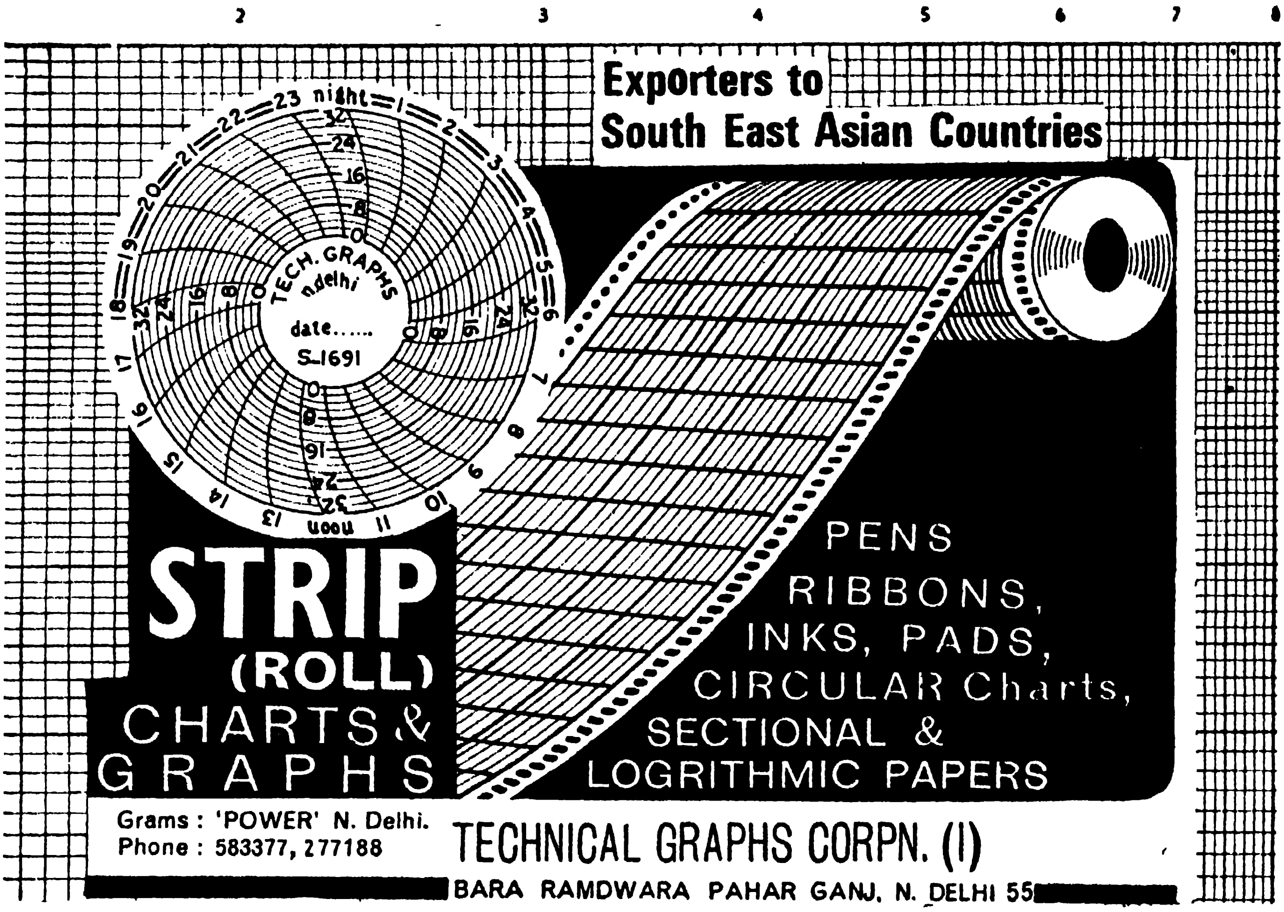

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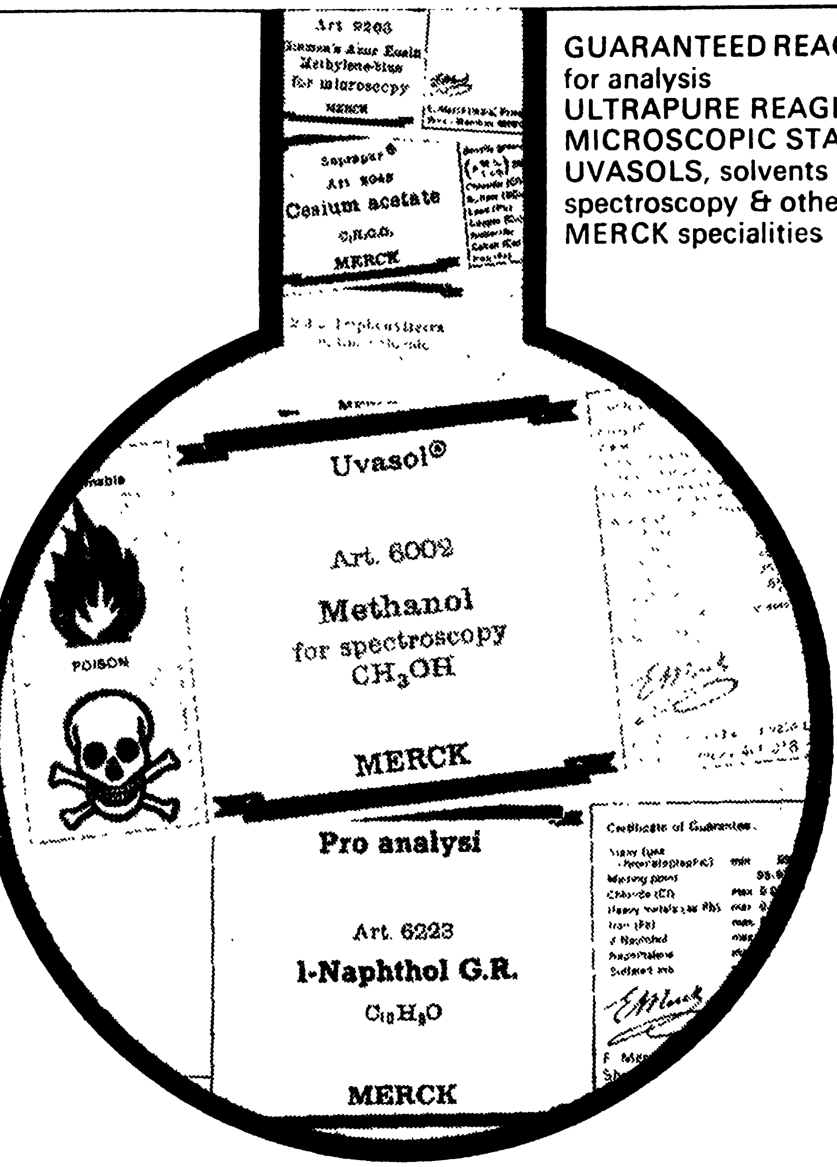

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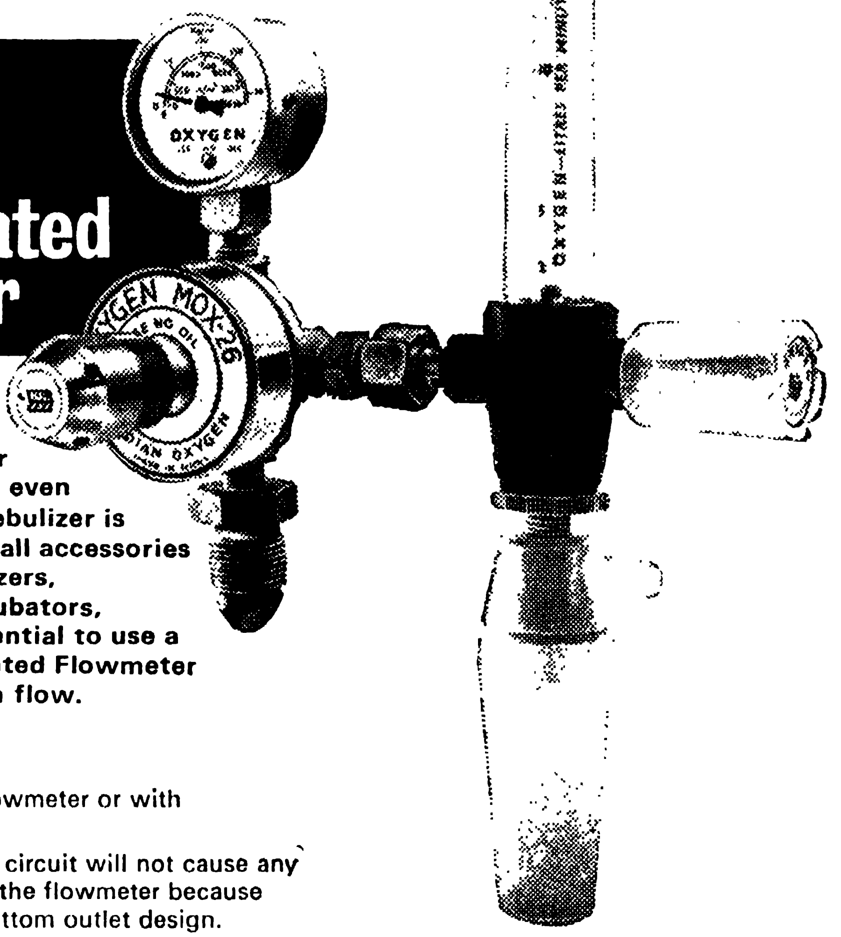

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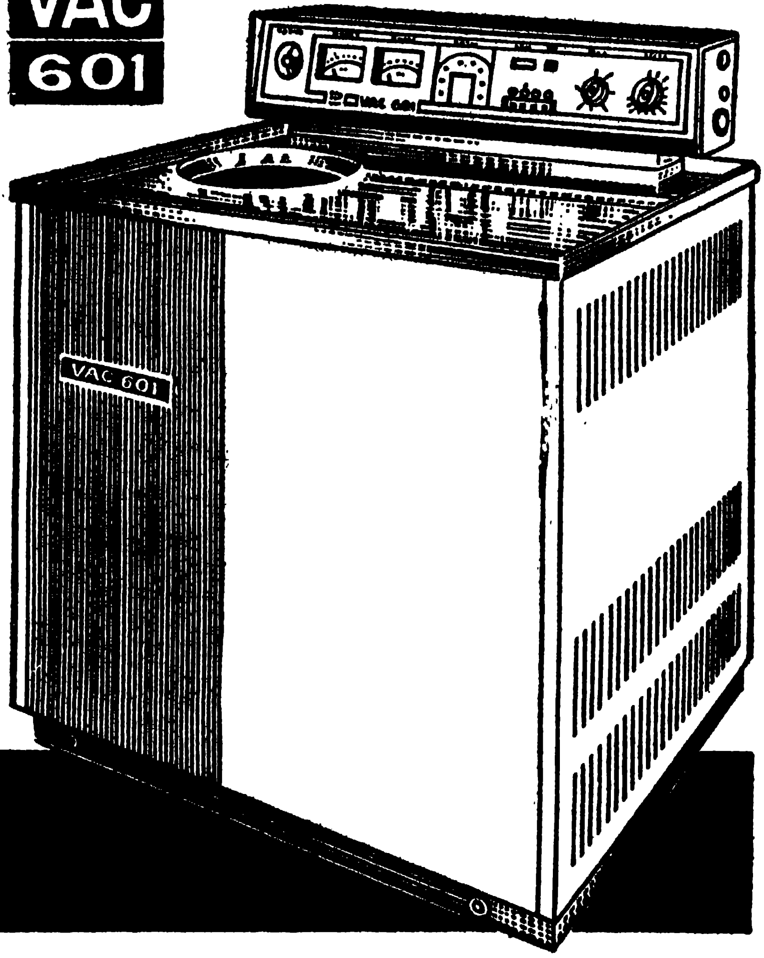

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VOL. 11 DECEMBER 1974 NO. 11

Cover : Bubble Memory Register. Magnetic bubbles are guided by Permalloy (soft magnet) elements deposited on the surface of the magnetic wafer in the form of stubby Y's and thin bars (*Courtesy : Scientific American*, Vol. 224, No.6)

★

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LETTERS

Cyanide

Sir, I thank you for publishing "Inorganic poisons and their antidotes" by Dr. D. Chakraborti (*S.R.* July, 1974). I would like to know the difference in action of CN ions in KCN NaCN as both K and Na are nonpoisonous.

BONDA R. RAO
Bilaspur (M.P.)

All soluble inorganic cyanides possess the toxic property. Cyanide poisoning is solely due to cyanide anion. Whatever the cation may be, sodium or potassium, the effect will be the same as their cyanides are water soluble.

D. CHAKRABORTI
Deptt. of Chemistry
Jadavpur University, Calcutta

Malignant diseases

Sir, I refer to Ramesh Chander Bhagat's letter on "Snake venom" (*S.R.* Feb., 1974). The third sentence, as it reads, almost presumes and categorises arthritis, neuritis, etc., under the heading malignant diseases. As far as the present medical terminology is concerned, the meaning of malignancy refers to cancer.

BASUDEB MANDAL
State Hospital
Nadia (W.B.)

Metric time

Sir, Whereas the author has touched upon many aspects of metric time (*S.R.* August, 1974) he has not mentioned an important aspect, that is, the unit metric second, for a physicist. In all units, the unit of acceleration and gravity has got its bearing on the present unit of second. When this unit is altered, acceleration, gravity and thereby force and weights will all be modified. This is, perhaps, the reason why metric time has not been advocated by scientists.

B. CHANDRAMOULI
Hyderabad

Suggestion

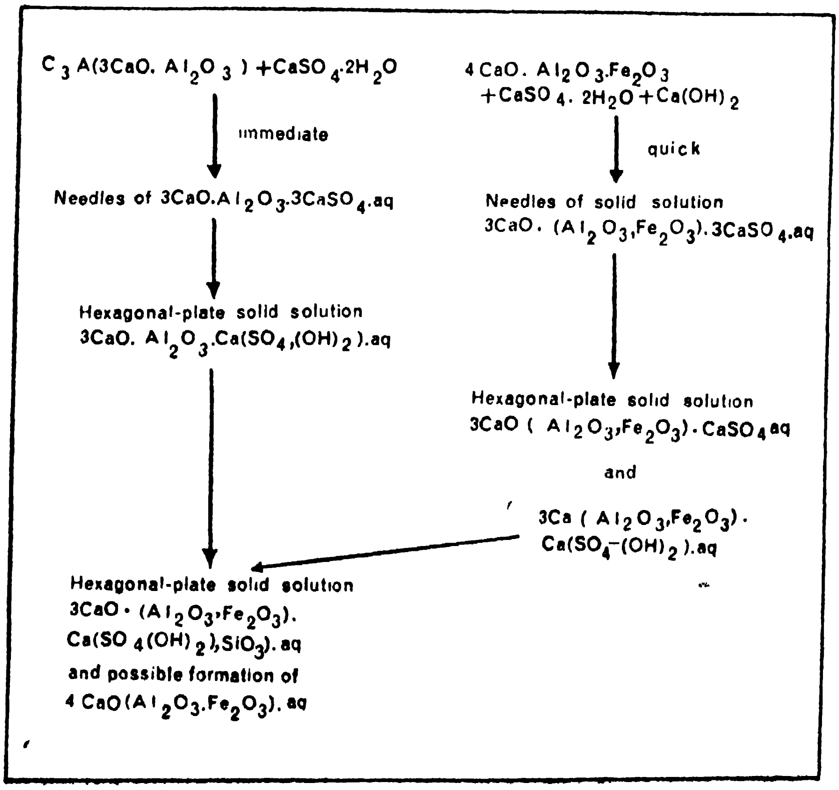
Sir, Will you please publish an article on how far quantum theory is able to explain the release of energy when lightning takes place.

P. SASIDHARAN
Chingleput, Tamil Nadu

Sawai Jai Singh

Sir, It would be best to let Sawai Jai Singh speak about himself in reply to the query of Hari Shankar Upadhyay (*S.R.* Sept.-Oct., 1974) about his interest in astronomy. In his introduction to *Zeech-i-Muhammadshahi* (in Persian) he allows himself to make an autobiographical observation about it. The literal translation into English by W. Hunter in 1798 reads:

"But since the well-wisher of the works of creation, and the admiring spectator of the theatre of the infinite wisdom and providence, Sawai Jai Singh, from the first dawning of reason in his mind, and during its progress towards maturity, was entirely devoted to the study of the mathematical sciences and the bent of his mind was constantly directed to the solution of its most difficult problems; by the aid of the Supreme Artificer he obtained a thorough knowledge of its principles and rules ....On representing it to His Majesty, (i.e., the then Mughal emperor, Muhammad Shah), he was pleased to reply: Since you, who are learned in the mysteries of science, have a perfect knowledge of this matter, having assembled the astronomers and geometricians of the faith of Islam, and Brahmins and pundits, and the astronomers of



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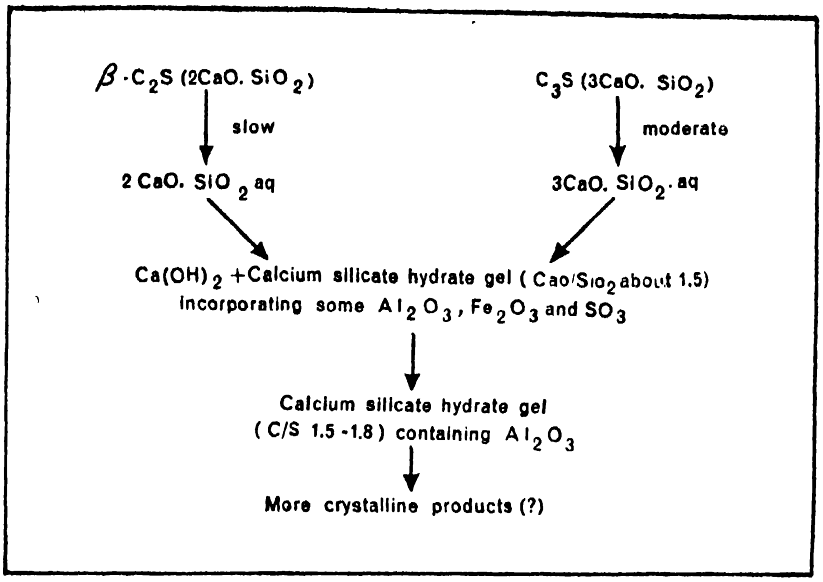
$3CaO.Al_2O_3.Ca(SO_4,(OH)_2).aq$
$4CaO.Al_2O_3.Fe_2O_3+CaSO_4.2H_2O+Ca(OH)_2$
quick
Needles of solid solution
$3CaO.(Al_2O_3,Fe_2O_3).3CaSO_4.aq$
Hexagonal-plate solid solution
$3CaO(Al_2O_3,Fe_2O_3).CaSO_4aq$
and
$3Ca(Al_2O_3,Fe_2O_3).Ca(SO_4-(OH)_2).aq$
Hexagonal-plate solid solution
$3CaO.(Al_2O_3,Fe_2O_3).Ca(SO_4(OH)_2),SiO_3).aq$
and possible formation of
$4CaO(Al_2O_3.Fe_2O_3).aq$

Fig. 1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C3S (3CaO. SiO2)
moderate
3CaO. SiO2.aq
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incorporating some Al2O3, Fe2O3 and SO3
Calcium silicate hydrate gel
(C/S 1.5-1.8) containing Al2O3
More crystalline products (?)

Fig. 2

Europe, do you so labour for the ascertaining of the point in question, that the disagreement between the circulated time of those phenomena and the times in which they are observed to happen may be rectified."

It may be noted that Jai Singh became the ruler of Amer, later to be transformed into the state of Jaipur by him, at the age of 13; and so he became a nobleman in the court of Aurangzeb, who was much impressed by Jai Singh's early attainments. This provided Jai Singh an opportunity to travel widely and to make the acquaintance of many men of learning to further satisfy his innate love of science. These were the "astronomers and geometricians" mentioned above, whom he gathered around him at his new capital in Jaipur and who became his constant collaborators all his life.

M.F. Soonawala
D-93, Bani Park
Jaipur

Cement

Sir, In "Cement and its constituents" (*S.R.* July, 1974), S.N. Ghosh has failed to mention that only the powder cement has the tendency to set, while the clinker cement does not. Besides, I would like to know:

The sequence of the setting process, **the actual reactions taking place in the form of chemical equations and the period for which the setting process proceeds.**

Mir Ahmed Ali
Madras University

The clinker particles owing to their extremely low surface area react with water with negligible speed; while cement which is a powder and has large surface area reacts much faster with water leading to the "setting and hardening" phenomenon.

The reactions of portland cement with water leading to "setting and hardening" are rather complex. A sequence of the reactions of the individual constituents which are present in portland cement is given in Figs. 1 and 2.

The "setting and hardening" of portland cement is an overlapping process and is dependent on mineralogical composition of the cement, temperature, water-cement ratio, etc. The setting time, however, can be manipulated by various admixtures. The setting time of ordinary portland cement may vary from little to a very long time; however specification permits it to vary with in 30 to 600 minutes. Average portland cement has about 100-200 minutes "initial setting" and 300-500 minutes "final setting" times.

S.N. Ghosh
Cement Res. Inst. of India
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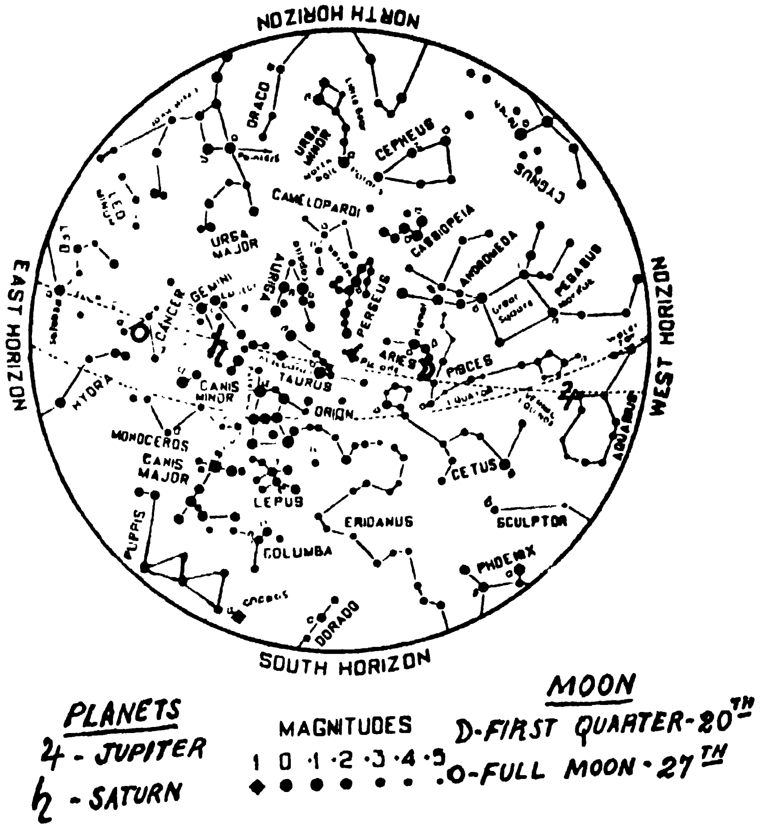
A HAPPY NEW YEAR

PLANETS AND THEIR POSITIONS—JANUARY 1975



The moon

NEW moon occurs on 12th at 3-50 p.m. and full moon on 27th at 8-39 p.m. I.S.T. The moon passes about one degree north of Mars in the early hours of 10th, six degrees north of both Mercury and Venus on 14th, about seven degrees north of Jupiter on 17th and two and a half degrees south of Saturn on 26th. The lunar crescent becomes first visible after the new moon day in the evening of 13th. The moon is at apogee or farthest from the earth on 16th and at perigee or nearest to it on 28th.

The earth is at perihelion or nearest to the sun on 2nd.

The planets

Mercury (Budha) reappears as an evening star in the second quarter of the month and sets about an hour after sunset. It passes about half a degree north of Venus on about 21st. It is at the greatest eastern elongation of about 19 degrees from the sun on 24th and becomes retrograde on 30th. It moves from Sagittarius (*Dhanus*) to Aquarius (*Kumbha*) through Capricorn (*Makara*). Its visual magnitude varies from —0.8 to +0.7.

Venus (Sukra), an evening star, sets about an hour after sunset during the month. It moves from Sagittarius (*Dhanus*) to Aquarius (*Kumbha*) through Capricorn (*Makara*). Its visual magnitude is about −3.4.

Mars (Mangala), visible in the morning sky, rises about two hours before sunrise during the month. It moves from Scorpio (*Vrischika*) to Sagittarius (*Dhanus*). Its visual magnitude is about +1.7.

Jupiter (*Brihaspati*), visible in the evening sky, sets about four hours after sunset during the first half of the month and about three hours after it during the second half. It is in Aquarius (*Kumbha*). Its visual magnitude is about —1.7.

Saturn (Sani) rises at about sunset and sets at about sunrise during the first half of the month being at opposition with the sun on 6th. During the second half it sets about an hour before sunrise. It is in Gemini (*Mithuna*). Its visual magnitude is about —0.2.

(*Source:* Nautical Almanac Unit of the Meteorological Office, Alipore, Calcutta-27).

MAGNETIC BUBBLE DEVICES

DIPANKAR SENGUPTA

The magnetic bubbles are cylindrical magnetic domains whose polarisation is opposite to that of the thin magnetic film in which they are embedded. They are stable over a considerable range of conditions and can be moved from point to point at high velocity making the memory storage 10 times faster than the present magnetic-disc memory systems

MAGNETIC materials are now extensively used in computer memories. Information can be stored as the magnetisation of magnetic discs and tapes or in terms of the direction of magnetisation of ferrite cores. Although the ferrite cores provide random access with microsecond retrival time, they are bulky and expensive. This makes the discs and tapes more popular inspite of considerable slowdown in the retrival rate (milliseconds) due to lack of random access. The movement of storage medium relative to the reading head requires mechanical parts and leads to higher probability of system breakdown.

All these problems have, in recent years, intensified the technological hunt for smaller, faster, cheaper and more reliable memories. A number of new techniques have been developed and explored for memory applications. Notable among them are, the large scale integration using semiconductors, magneto-optic memory and the magnetic 'bubble' domain devices.

The bubble domain technology has now reached the point where it is destined to play a leading role in the future development of computer hardware. The properties of magnetic domains and how they can be utilised for memory and logic functions are discussed in this article.

What is a 'bubble' domain?

The atoms in a ferromagnetic material experience a force called "exchange force". This force has its origin in the interaction between the 'spinning' electrons of adjacent atoms. This force keeps the atomic moments aligned with respect to each other. However, the exchange forces do not determine the absolute direction of atomic moments but only the relative moments within each group.

The absolute direction is determined by the interplay of a number of forces: the magnetocrystalline field, internal and applied magnetic fields, and the magnetostatic field. The magnetocrystalline field tends to align the atomic moments along specific crystallographic directions that are referred to as the "easy" directions. All the materials that are discussed here have a single easy direction. An applied field tries to turn the atomic moments along its direction. The magnetostatic energy is created by discontinuities and surfaces in the material. Normally this force is rather small for bulk magnetic materials. But in thin films, where the ratio of surface area to volume is very high, it plays a significant role. This field opposes the magnetisation of the material. Under the action of these forces the magnetic material organizes itself into adjacent volumes or "domains" magnetised in different directions. A typical domain structure is shown in Fig. 1(a). The domains are separated by "domain walls" that are several hundred atomic planes wide. The atomic moments within the wall change their direction continuously from one domain to the other as shown in Fig. 1(b). The domain walls store energy but their creation reduces the magnetostatic energy. Hence a particular domain

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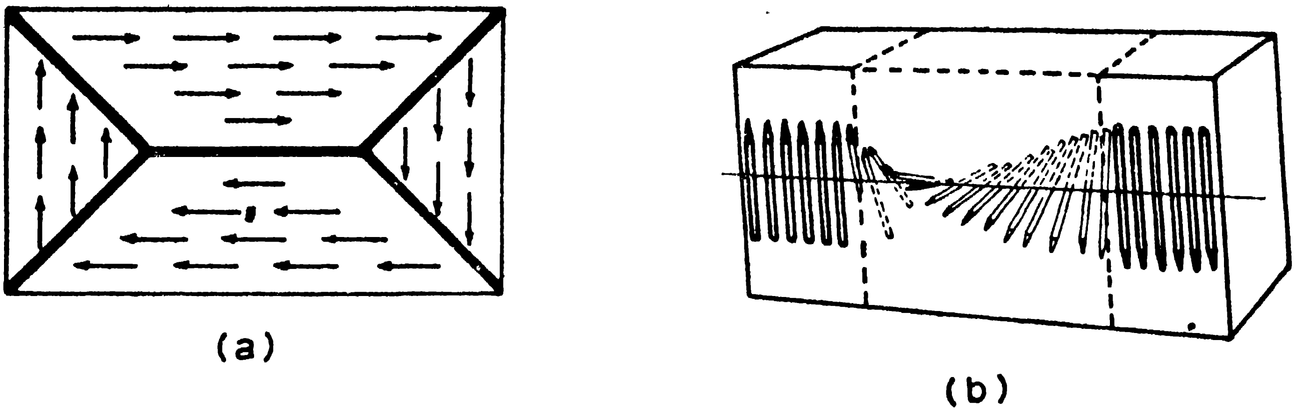

Fig. 1. Magnetic domains, (a) domains in a ferro-magnetic plate and their directions of magnetisation; (b) a magnified picture of domain wall shows how the atomic moments change across the wall

pattern is a minimum energy state where a compromise has been reached between the cost of establishing walls and the magnetostatic energy reduction they cause.

The materials suitable for supporting "bubble" domains are prepared into thin sheets or films of few tens of microns ($1\mu = 10^{-4}$ cm) thickness with the easy direction normal to the plane of the film. In the absence of a magnetic field the intertwined strip domain pattern as shown in Fig. 2(a) is observed. On application of a magnetic field along easy direction, domains magnetised against the field shrink in area (since the applied field increases their energy) with respect to those magnetised along the field direction. On increasing the field to a critical value, the strip domains converge into isolated cylindrical domains popularly known as "bubbles" (Fig. 2(b)). Further increase of field reduces the bubble size and finally they disappear. Bubble technology involves the creation and manipulation of these cylindrical domains.

The material problem

The research and development in the initial stage was primarily devoted to the search of a suitable material. In order that the bubble technology may provide an economic alternative to conventional computer memories, it must satisfy very stringent requirements some of which are listed below:

(a) The packing density of one million per square inch restricts the

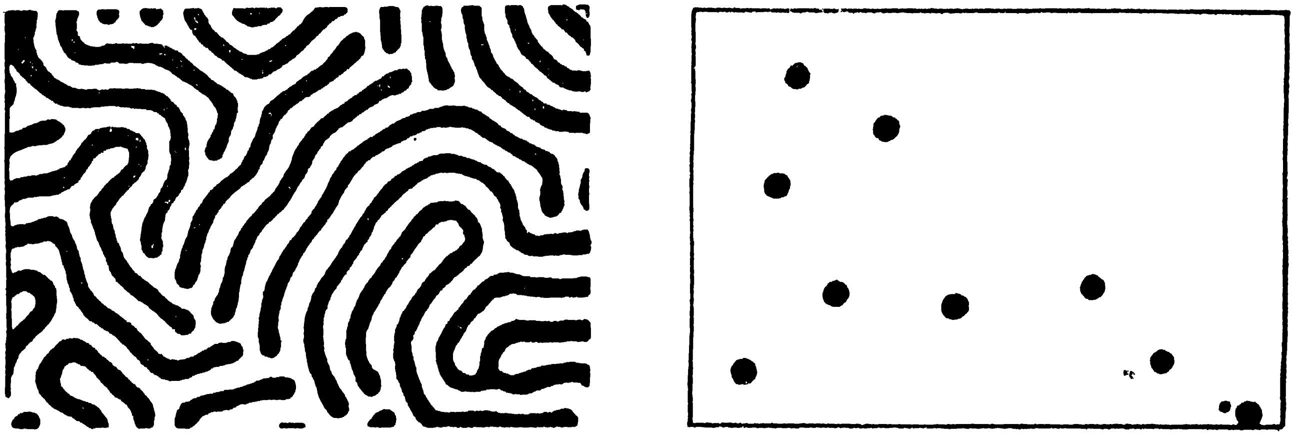

Fig. 2. (a) Strip domains as observed in orthoferrite or garnet platelets, (b) the strips collapse into bubbles as the critical field is reached

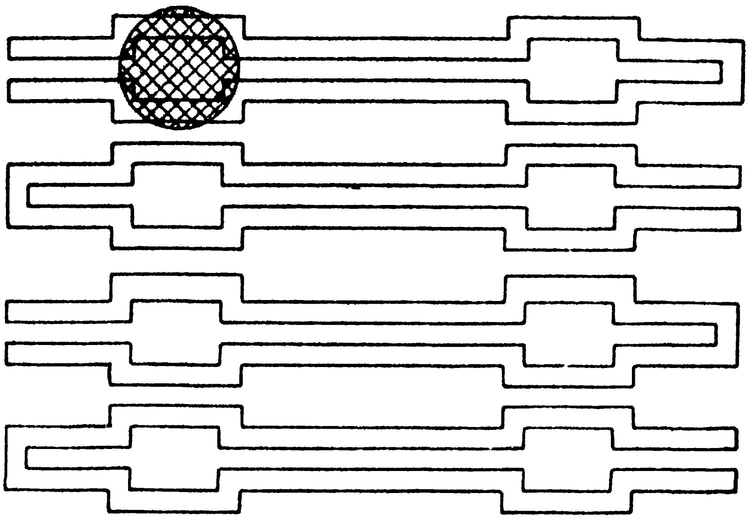

Fig. 3. Conduction loop pattern for one-dimensional shift registrar

maximum bubble diameters to about 7.5 microns. This requires a film thickness of same magnitude and constant within 1%.

(b) It has already been pointed out that the easy direction should be normal to the film. Magnetisation should be low enough (about 150 gauss) for anisotropy to overcome the tendency of the magnetisation to lie in the plane of the sheet, thereby reducing the pole area and magnetostatic energy. Ideally the anisotropy field, that is, the field necessary to turn the magnetisation from easy direction to the plane of the film, should be at least 1.5 times the magnetisation.

(c) As to speed, a minimum mobility of 200 cm/sec/ Oersted (i.e., a magnetic field gradient of 1 Oersted in the plane of the film should move the bubbles at the rate of 200 cm/sec) is required. From material standpoint this means a low domain wall coercivity, so that the walls can move freely in response to in-plane magnetic fields.

(d) The film should be nearly defect-free. In actual device applications the number of defects should be less than 5 per square centimeter.

Historically, the first set of magnetic materials used were the rare earth orthoferrites. They are mixed oxides of iron and rare earths with a chemical formula of $RE\ FeO_3$. The orthoferrites were grown by the $PbO\text{-}PbF_2$ flux method. The presence of flux lowers the melting point of the oxide mixture considerably (from 1300°C to 900°C). The whole molten mixture contained in a platinum crucible is slowly cooled (2-4°C/hr) to get the single crystals. The flux method is difficult, expensive and time-consuming. Very large melts (20 kg) are needed to produce homogeneous crystals. One rarely gets crystals larger than 1 sq. cm in size and flux inclusions are always present. The slicing of film few microns thick and giving it a good polish call for very high technical skill. To add to the problems, the minimum bubble size observed in orthoferrites was only 50 microns. The size could be lowered by choosing compounds having a magnetic phase transition point near room temperature. This, however, made the bubble size and mobility highly temperature-sensitive thereby limiting the device stability. At this stage prospects of mass production bubble domain devices looked gloomy indeed.

Then came an unexpected breakthrough; it was found that some synthetic rare earth garnet crystals could support bubbles of much smaller dimensions (8 microns) than those in orthoferrites. It was an unexpected result since the garnets are cubic crystals and laws of magnetism do not permit such crystals to be uniaxial. Small strains in the crystals introduced during the growth are actually responsible for this uniaxial property. It was soon found out that single crystal magnetic garnet films could be deposited on other non-magnetic garnet single crystals (substrates) by the process called "liquid phase epitaxy". The most common substrate is gadolinium gallium garnet ($Gd_3Ga_5O_{12}$) that can be grown by a method developed by Czochralski. A "seed" (small) crystal is dipped into the molten garnet kept in an irridium crucible and heated by a radio-frequency generator (temperature required is above 1500°C). The seed is rotated

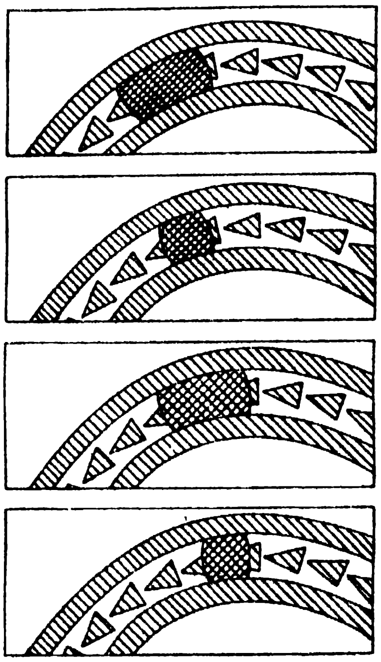

Fig. 4. Domain propagation along angel fish circuit utilising a pulsating biasing field

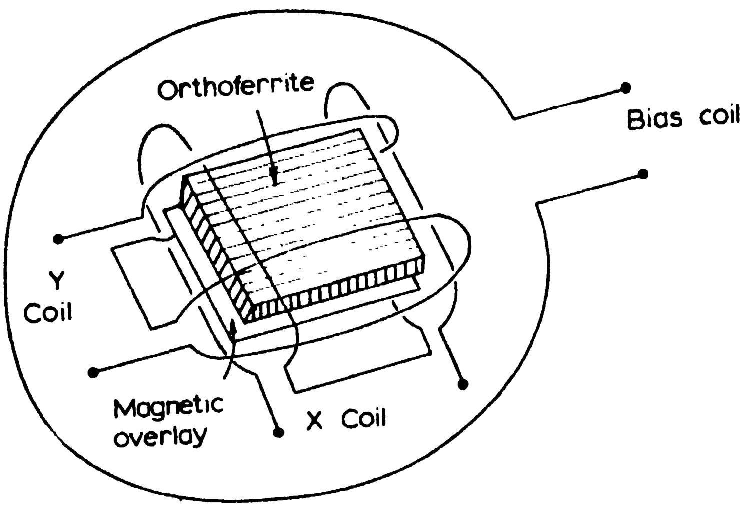

Fig. 5. Layout of a magnetic device that uses a rotating magnetic field for bubble propagation

and slowly withdrawn. By adjusting the withdrawal rate and power input, one can grow large cylindrical crystals. The crystal is then cut, polished and dipped in a melt of magnetic garnet material (e.g., $Er_3Fe_5O_{12}$) for epitaxy. This growth technique is much faster than flux method and can be adopted for routine industrial processing. The substrate also provides the mechanical strength that was absent in orthoferrite slices. The magnetic properties of the garnets are not temperature-sensitive. They also have a lower anisotropy constant and consequently higher mobility. All major industries have now abandoned orthoferrites in favour of garnets as the most promising bubble material.

Manipulation of bubbles

While the search for the right material was on, the technologists had already started fabricating devices for the creation, annihilation, transfer, interaction and detection of bubbles. Bubbles are easily generated from a starting bubble by "slicing" it electronically by pulsing the current through a conductor loop placed above it. Slicing requires about 50 to 100 gauss field. On the other hand, annihilation of bubble is a low energy process and usually an increase of biasing field locally by a few gauss is sufficient.

One of the earliest devices constructed using the "bubbles" was the shift registrar. This consists of a series of conducting loops placed on the magnetic film as shown in Fig. 3. If a suitably directed current is passed through a conductor near a bubble, a magnetic field is produced that attracts the bubble under the current loop. A one-dimensional shift registrar (Fig. 3) is operated by energising the successive loops in turn. Motion is easily extended to the second dimension by adding conductor loops at right angles to the first set.

A second method of propagation uses the fact that the diameter of the bubbles can be modulated by modulating the biasing field. Motion is achieved by manoeuvering these pulsating bubbles in and out of asymmetrical energy traps. The traps are created by wedge-shaped thin films of high permeability Permalloy (an alloy of iron and nickel that can be magnetised and demagnetised easily) placed in contact with the magnetic film. They are called the "angel fish" circuits and Fig. 4 shows the motion of the bubble.

In the third and most commonly used method of propagation, a field rotating in a plane acts on a structure of Permalloy pattern and thereby produces bubble motion. The overall geometry of such a device is shown in Fig. 5. The bias coil provides the transverse field needed for supporting the domains. The X and Y coils are switched and reversed sequentially to produce the effect of rotating in-plane field. A variety of Permalloy patterns have been used for guiding the bubbles. The operation of one such pattern, the "T-bar", is shown in Fig. 6(a). In-plane field has little effect on the bubbles but produces magnetic poles on the Permalloy circuit. Rotation of in-plane field causes systematic redistribution of the poles and the bubbles respond by moving. With one full rotation of the field, domains advance by one period of the circuit. A T-bar shift registrar has been operated at data rates faster than 300,000 bits per second and at densities greater than one million bits per square inch. A domain generator suitable for use with T-bar pattern is shown in Fig. 6(b). Its operation is easy to understand from the figure.

Logic circuits

It has been found that bubbles separated from each other by a distance more than thrice their diameter, do not interact with each other. If they are brought any nearer they exert repulsive force on each other. Although such interactions limit the storage density, they are extremely useful for developing bubble logic circuits.

Two typical logic circuits are shown in Fig. 7. Fig. 7(a) demonstrates an AND-OR logic circuit. The AND logical function can be stated as "if proposition A is true,

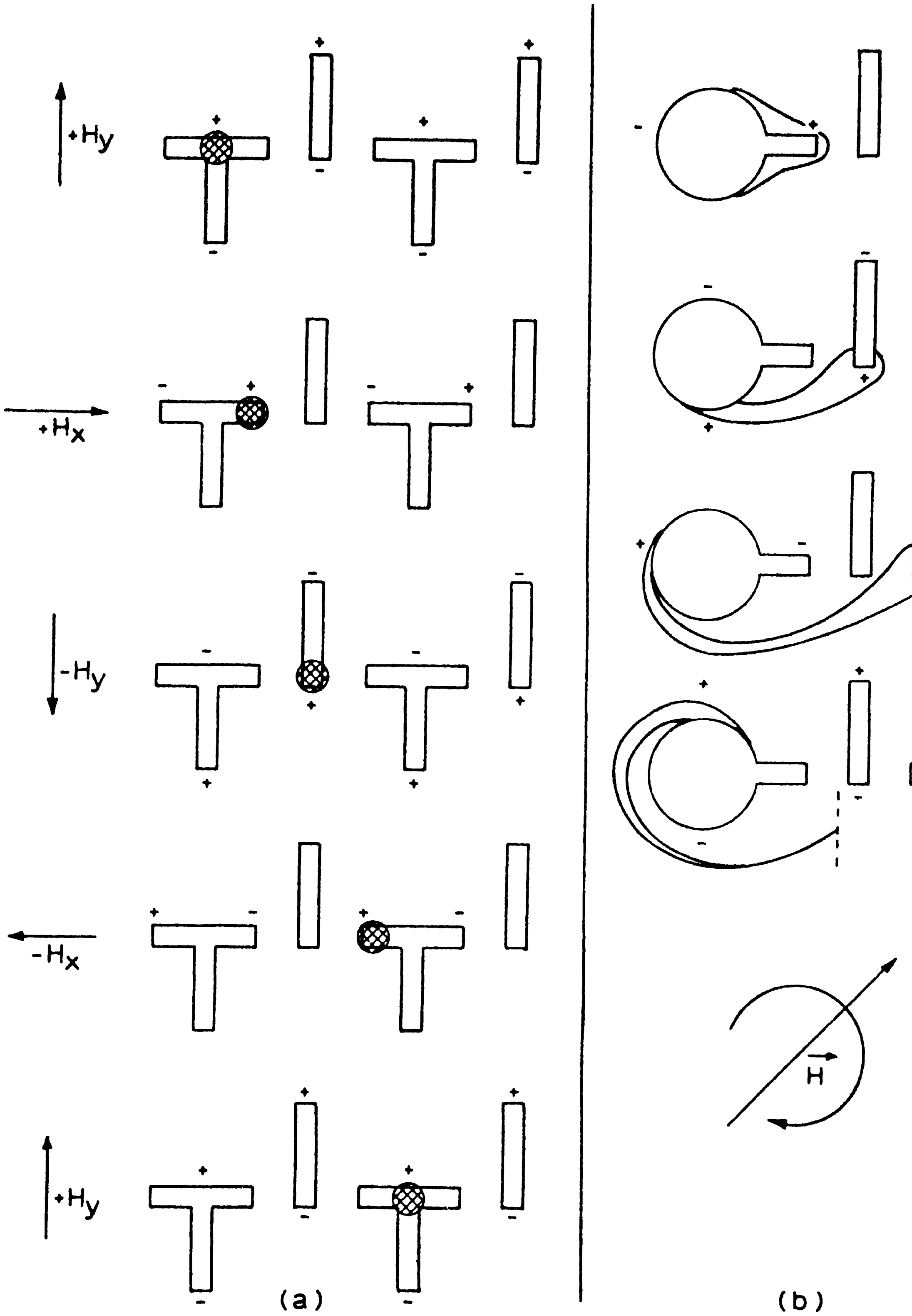

Fig. 6. (a) T-bar Permalloy pattern and domain propagation under the action of a rotating magnetic field;
(b) domain generator for T-bar circuit

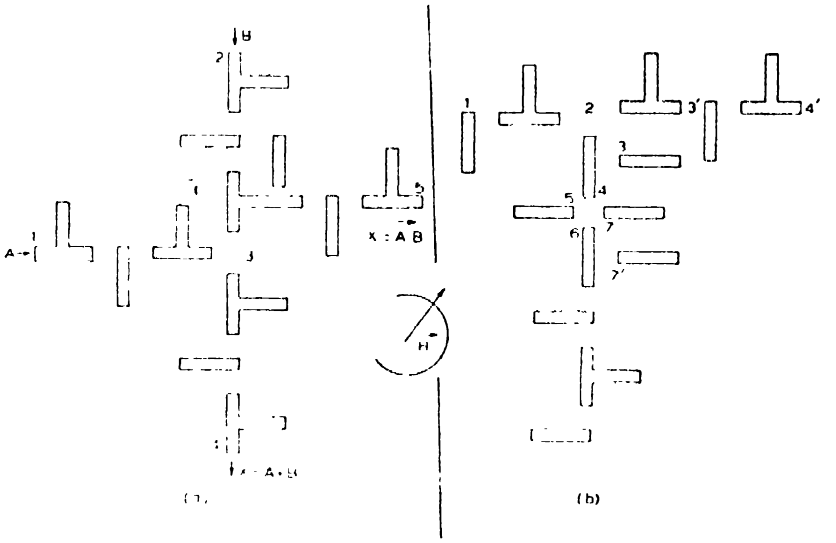

Fig. 7. Bubble logic circuits: (a) circuit for AND-OR logic function, (b) a domain flip-flop

AND proposition B is true...., then some specific result X is true". Channels A and B in Fig. 7(a) transmit information regarding propositions A and B respectively. Presence or absence of a bubble in the channel can be identified with the truth and falsehood of the corresponding proposition. If a bubble propagates along 1-3 or A channel [Fig. 7(a)], then on reaching 3 it is diverted into 3-4 direction by the particular Permalloy configuration. A bubble coming along 2-3 direction or B channel would continue along 3-4. If two bubbles propagate simultaneously along 1-3 and 2-3 channels, then due to their mutual repulsion the bubble coming along 2-3 is diverted along 3-5. Hence the presence of bubble in 3-5 track indicates the simultaneous arrival of bubbles along A and B channel. This is indicated in Fig. 7(a) in terms of Boolean algebra as $T = AB$(.) signifies logical AND connective.

The OR logical function can be stated as "if proposition A is true, OR proposition B is true,.... then some specific result X is true." It is easy to see that presence of bubble in 3-4 channel indicates A OR B, i.e., $X = A + B$.

Fig. 7(b) is domain flip-flop circuit. A bubble domain propagating along 1-2 path has two alternative paths on reaching 2, namely, 3-4 and 3'-4'. The position 3 is preferred because of its proximity to 2. Then the bubble reaches 4 and gets trapped in the 4, 5, 6, 7 position. This is called the 'idler' position. Let us now follow the progress of a second bubble domain when the idler position is filled. As it reaches 2, it interacts with the idler bubble located at 6. The interaction forces the new arrival to take the 3'-4' track. Simultaneously the domain at 6 is pushed to 7' and thereby is released from the idler position. Now both the bubbles move away leaving the idler empty. Presence or absence of a bubble in the idler determines the state of the flip-flop. A binary counter (the counter that counts in units of two) can easily be constructed by utilising the output of one stage as the input of the next stage.

Detection of bubbles

The functioning of digital systems are of course dependent on detection of presence or absence of bubbles. Since the bubbles are tiny, fast moving domains with very small energy associated with them, their detection poses a difficult problem. A number of methods have been tried so far.

A useful property of both orthoferrites and garnets is their transparency to optical radiation. This permits the domains to be observed and photographed under a microscope using polarized light. The magnetisation of the domains can rotate the plane of polarization of incident radiation. The bubbles and the remaining regions of the magnetic film are magnetised in opposite directions. Hence, they rotate the polarization direction of incident radiation in opposite directions as well. Different fractions of light coming from these regions are transmitted by the analyser. Consequently, the domains are seen as clearly defined light and dark regions. Using high speed stroboscopic method, it has been possible to follow the bubble motions.

A second method utilises the fact that a moving bubble produces a transient magnetic field that can interact with current in a conductor pick up coil.

A third method consists of measuring the voltage generated in a silicon "Hall" probe. This utilises the principle of Hall effect (a magnetic field induces a voltage in a direction normal to the direction of propagation of a current through a conductor, silicon in the present case). The change of resistance of Permalloy overlays, due to the changing magnetic field generated by a passing bubble, can also be used for bubble detection.

Conclusion

It is difficult to believe that the pioneering work in this field by

(Continued on page 537)

THE WONDERWORLD OF PETROCHEMICALS

SUKUMAR MAITI

Recent energy crisis and the price hike of crude oil by Arab countries have effected the future of petrochemicals, particularly where crude oil and natural gas are scarce

PETROLEUM or crude oil offers to-day an infinite source of wealth for man. Through the magic wand of chemistry and chemical engineering oil may be converted into fuels to generate power, drugs to combat diseases, dyes to add colour in life, cosmetic to enhance beauty, perfumes for sensuous living, synthetic fibres for attractive easy-care apparels, and plastics—a material for to-day, tomorrow and, may be, day-after. All these chemical fantasies are made possible by the ingenious technology of petrochemical process industry.

Petrochemical technology represents one of the most highly advanced and progressive frontiers of scientific and engineering endeavour. The advancement made in this field is so rapid that almost everyday a new product or a modification of existing products is appearing in the consumer market.

What are petrochemicals?

Chemical compounds that are recovered or derived from petroleum or natural gas are called petroleum chemicals or, in short, petrochemicals. However, petrochemicals are in no way different from corresponding chemicals obtained from non-petroleum sources. These are mostly organic compounds having identical chemical composition, structure and properties to those of corresponding organic compounds. For example, methyl alcohol obtained from petroleum or natural gas hydrocarbons is exactly identical to methyl alcohol produced by the destructive distillation of wood. The name petrochemical refers only to the origin of the product.

Growth and development

Organic compounds were formerly thought as special compounds that can only be produced by living systems. This concept led to the birth of "Vital Force Theory". However, it was shown later that these organic compounds could be easily prepared without the help of a living organism. This gave rise to the beginning of synthetic organic chemistry—a branch of chemistry by which organic compounds of nature could be produced out of simple raw materials like coal, water, air, etc., in laboratories and factories.

In the early years of the development of synthetic organic chemistry coal and agricultural products served as the raw materials. With the population growth and the progress of civilization, the demand for various synthetic organic chemicals became so large that the supply from the traditional sources of raw materials for organic chemicals could not cope with. Moreover, the availability of agro-based materials, e.g., cotton, rubber, sugarcane, beet, etc., is unreliable and irregular because the supply of these materials depends upon the natural environments like, rain, weather, floods, etc. This prompted to explore alternative and independent sources of supply for these materials. Naturally, this led to the development of synthetic materials that are comparable substitutes for natural essential commodities. Thus the demand for raw materials for synthetic organic substitutes resulted in the genesis of petrochemicals. Petroleum serves today as

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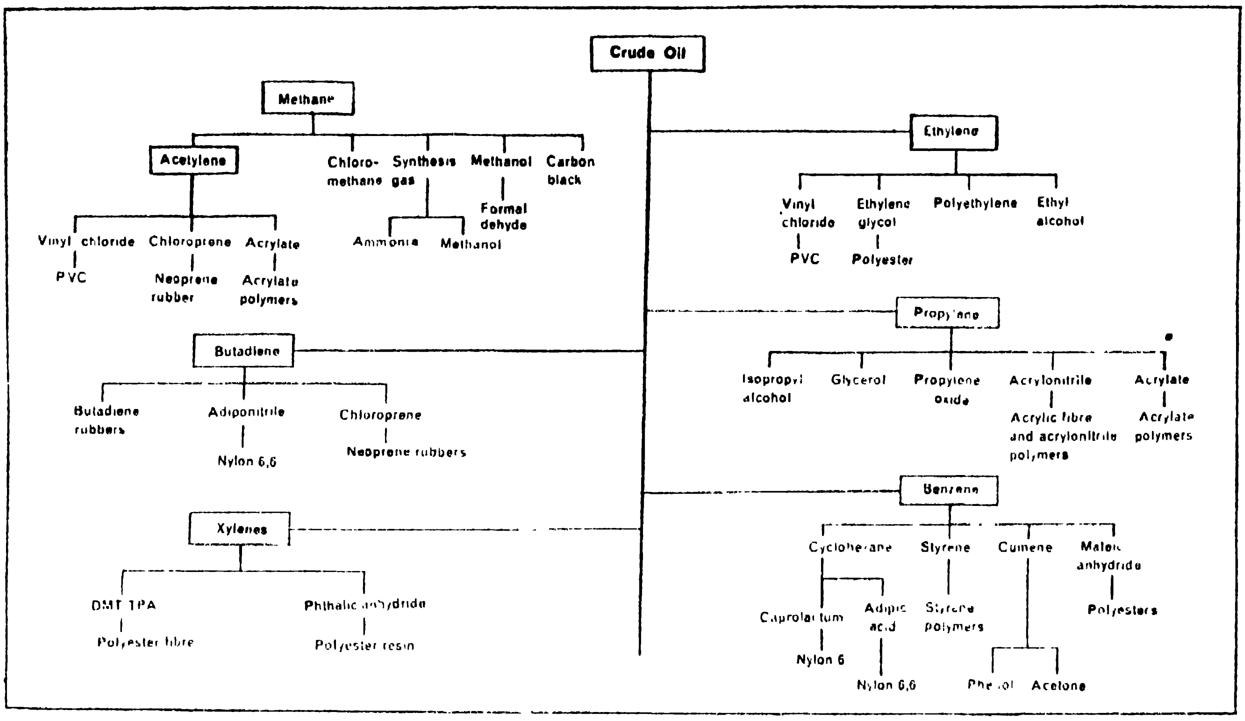

Fig. 1. Chemicals from petroleum

the most valuable and abundant source of raw materials for organic chemicals. Almost 90 % of the total production of organic chemicals is from petroleum. The basic building blocks of the vast petrochemical empire consist of simple hydrocarbons such as methane, ethane, propane, butane, ethylene, propylene, butylenes, acetylenes, butadiene, benzene, xylenes, etc. (Fig. 1). Although petroleum or crude oil serves as the premier source of raw materials for organic chemicals, only 8 % of the total world crude oil production is used as the petrochemical feedstock, the rest is consumed as energy.

The first petrochemical is isopropyl alcohol, which was produced in 1918 by Carleton Ellis in the USA by the indirect hydration of propylene by sulphuric acid. The propylene used was obtained from petroleum refining and hence the process was called the "Petro-alcohol" process. This process is practised even today.

Following this discovery, E.I. du Pont de Nemours & Co., U.S.A. manufactured the well-known anti-knock compound tetra-ethyl lead (abbreviated as TEL) for gasoline from petroleum. In subsequent years methanol, acetaldehyde and formaldehyde were synthesised from petroleum raw materials. During that period synthetic route to glycerine was tried with limited success in India.

However, the rapid growth and development of petrochemicals industry was due to the outbreak of World War II. Demands for explosives, substitutes for natural rubber and other materials led to the development of synthetic ammonia for making nitric acid and nitroglycerine explosives, toluene for TNT, styrene for styrene-butadiene rubber (known as SBR), and a host of other chemicals from petroleum.

During the post-war period quite a number of remarkable discoveries in the polymer and catalysis fields gave further boost to the rapid development of petrochemicals industry. For example, the discovery of Ziegler catalysts for low pressure polymerization of ethylene, and stereospecific polymerization of propylene acted as great stimulants for development of ethylene and propylene production from petroleum feedstocks.

Sources of petrochemical feedstocks

Crude oil and natural gas are the two ultimate sources of petrochemical feedstocks (Fig. 2). Crude oil is a complex mixture of dissolved gas and solid in liquid hydrocarbons. The hydrocarbons mostly consist of aliphatic, alicyclics (also known as *naphthenes*), and aromatics containing one to about forty carbon atoms. This complex mixture of hydrocarbons in crude oil may be separated into various fractions having close-boiling components by distillation. Distillation practised for fractionation of crude is of two types: atmos-

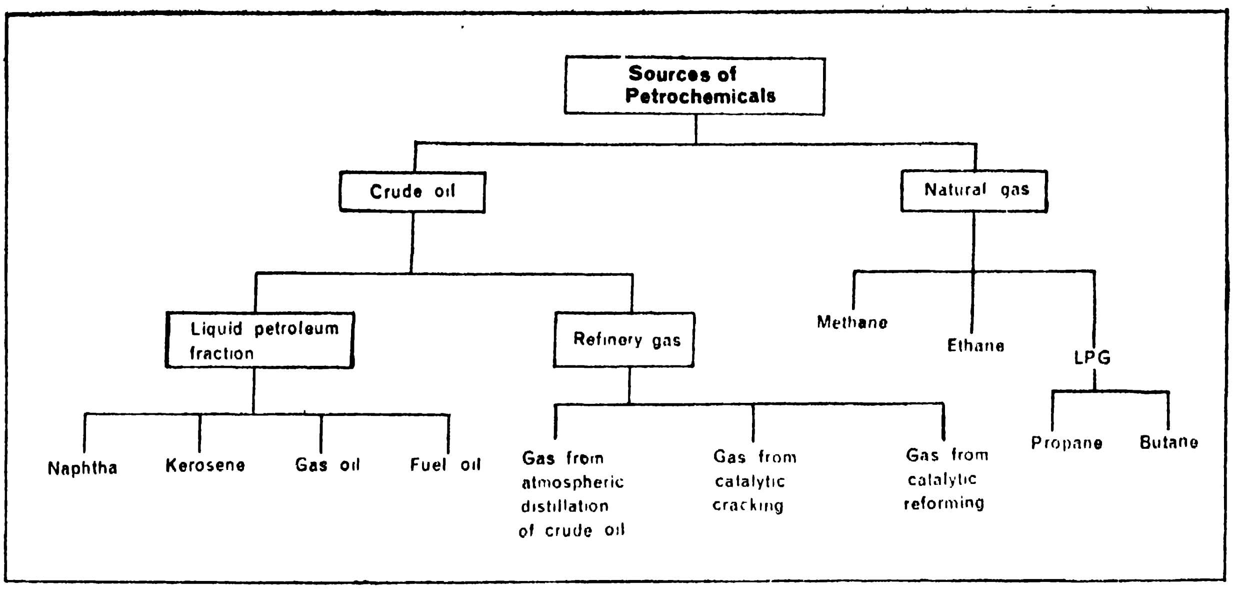
Sources of Petrochemicals
Crude oil
Natural gas
Liquid petroleum fraction
Refinery gas
Methane
Ethane
LPG
Naphtha
Kerosene
Gas oil
Fuel oil
Gas from atmospheric distillation of crude oil
Gas from catalytic cracking
Gas from catalytic reforming
Propane
Butane

Fig. 2. Sources of petrochemicals

pheric distillation; and vacuum distillation.

During atmospheric distillation dissolved gases in crude oil are obtained as the overhead product while the liquid is separated into various fractions. The heavy residue which cannot be fractionated by atmospheric distillation due to the high boiling points of the components is further fractionated by vacuum distillation (Fig. 3). These liquid fractions obtained by atmospheric and vacuum distillation of crude oil serve as energy and petrochemicals feedstocks.

Natural gas, which essentially consists of methane, together with other gases from petroleum refining operations known as "refinery gases", also constitutes petrochemicals feedstocks.

Classification

Petrochemicals represent a broad spectrum of chemicals from simple hydrocarbons like methane or ethylene to complex compounds such as plastics, pesticides and pharmaceuticals. They may, however, be classified as (a) first generation, (b) second generation, and (c) third generation petrochemicals. However, this classification is somewhat arbitrary.

First generation. These are chemicals directly available from crude oil by subjecting the latter to various physical or even chemical treatments. Such physical and/or chemical treatments include distillation, isomerization, cracking, etc. Examples of such chemicals are methane, ethane, propane, butane, ethylene, propylene, butylenes, acetylenes, butadienes, benzene, toluene and xylenes (known collectively as BTX). These generally represent the basic petrochemicals.

Second generation. These chemicals are usually the derivatives of the first generation petrochemicals. Styrene (derived from benzene and ethylene), dimethyl terephthalate (produced from *p*-xylene), acrylonitrile (obtained from propylene), etc., are examples of the second generation petrochemicals. This class constitutes the intermediate chemicals which serve as the raw materials for consumer industries like plastics, synthetic rubbers, fibres dyes, detergents, etc.

Third generation. These represent the consumer end-products and are derived mainly from the second generation petrochemicals. Examples of this class are polystyrene (from styrene), polyvinyl chloride (from vinyl chloride), DDT (from chlorobenzene), azo dyes (from aniline) polyester fibre (from dimethyl terephthalate and ethylene glycol), etc.

How are petrochemicals obtained?

Petrochemicals are produced from the basic raw materials, e.g., ethylene, propylene, butadiene, benzene, xylenes, etc., by various synthetic routes. For example, polyethylene, the plastic material from ethylene, is obtained by polymerizing ethylene, while ethylene oxide is produced by the oxidation of ethylene by air or oxygen. The reactions for petrochemical synthesis are carried out in presence of suitable catalysts. Many of the new developments and improved routes to petrochemicals are due to the discovery of new and better catalysts.

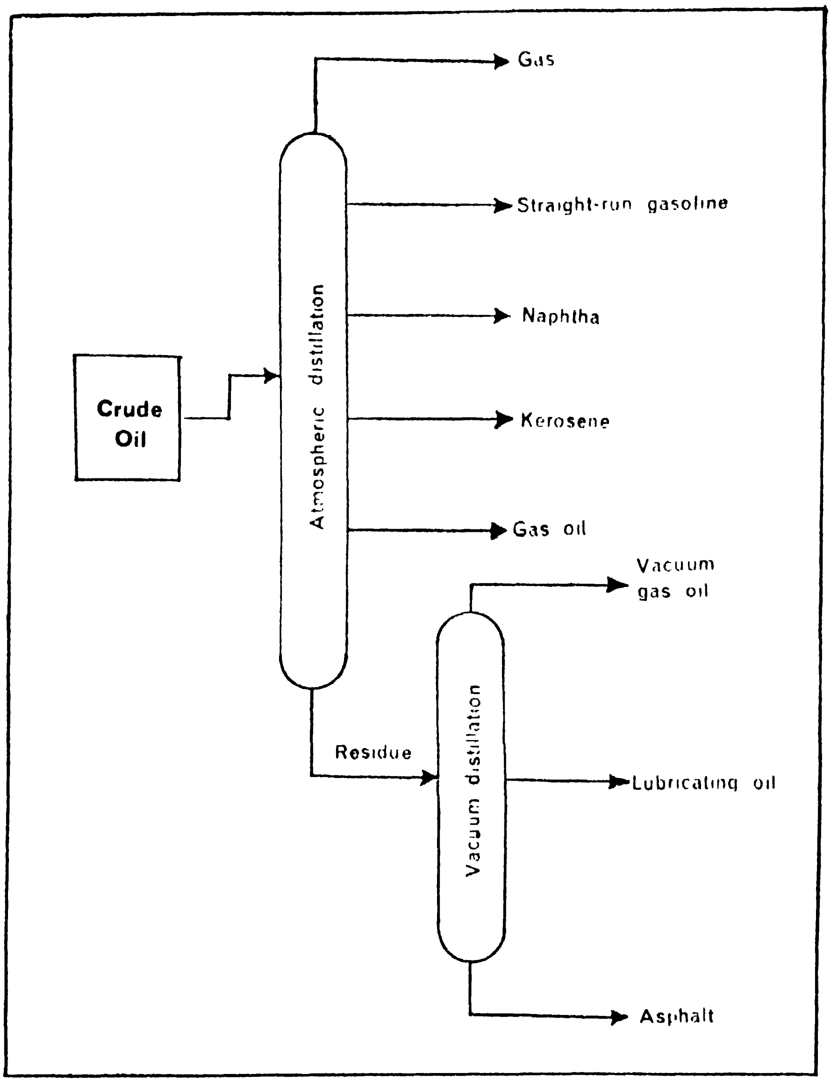

Fig. 3. Distillation of crude oil

Benzene is the most important of all aromatic basic raw materials. It may be hydrogenated to cyclohexane which is the starting chemical for nylon-6 plastics, adipic acid and hexamethylene diamine. The latter two are required for the synthesis of nylon-6,6 polymer. Benzene may also be converted to phenol, aniline, styrene and even maleic anhydride. All these products from benzene are very useful as intermediates for pesticides, dyes, pharmaceuticals, rubber chemicals, explosives and plastics (Fig. 4).

Impact of petrochemicals on modern living

It has already been said earlier that almost 90% of all organic chemicals produced to-day are from petroleum. Almost every facet of modern living, therefore, involves directly or indirectly one or the other petrochemical. Coal was formerly looked upon as the major source of raw materials for organic chemicals. But cheap and abundant availability of basic raw materials from crude oil and its flexibility of conversion into various chemical intermediates almost completely replaced coal as a feedstock for chemicals. For example, petroleum-derived naphtha has been increasingly used for fertilizer production and to-day fertilizers have become the largest volume petrochemicals. Even in India naphtha-based fertilizer plants have of late, wrongly or rightly, restricted the use of the coal-based process.

The second largest volume petrochemical are the synthetic polymers. The production of polymers at present has already surpassed the total production of all non-ferrous metals. It has been estimated that the total tonnage of plastics production will even exceed that of steel in 1985. This phenomenal growth of polymers is due partly to the low cost of production which, in turn, is related to the availability of cheap petrochemicals feedstocks.

Similarly in other areas petrochemicals have got an edge over non-petroleum based synthetic materials. For example, modern pesticides, pharmaceuticals, synthetic detergents, etc., are mostly derived from petroleum. Necessities, comforts and luxury of modern living are so much dependent on petrochemicals that it is almost a retreat to barbarism without petroleum. It has very clearly been reflected in the recent energy and chemical feedstock crisis due to the Arab oil embargo.

Future of petrochemicals

Recent energy crisis and the price hike of crude oil by Arab countries have made the future of petrochemicals rather bleak, particularly in countries where crude oil or natural gas is scarce. At present the demand for naphtha which is primarily used as the cracking feedstock for olefin (i.e., ethylene, propylene, butadiene and butenes) production is far outstripping its supply. This has led to exploring heavier petroleum fraction such as gas oil or fuel oil as the feedstock for olefin production.

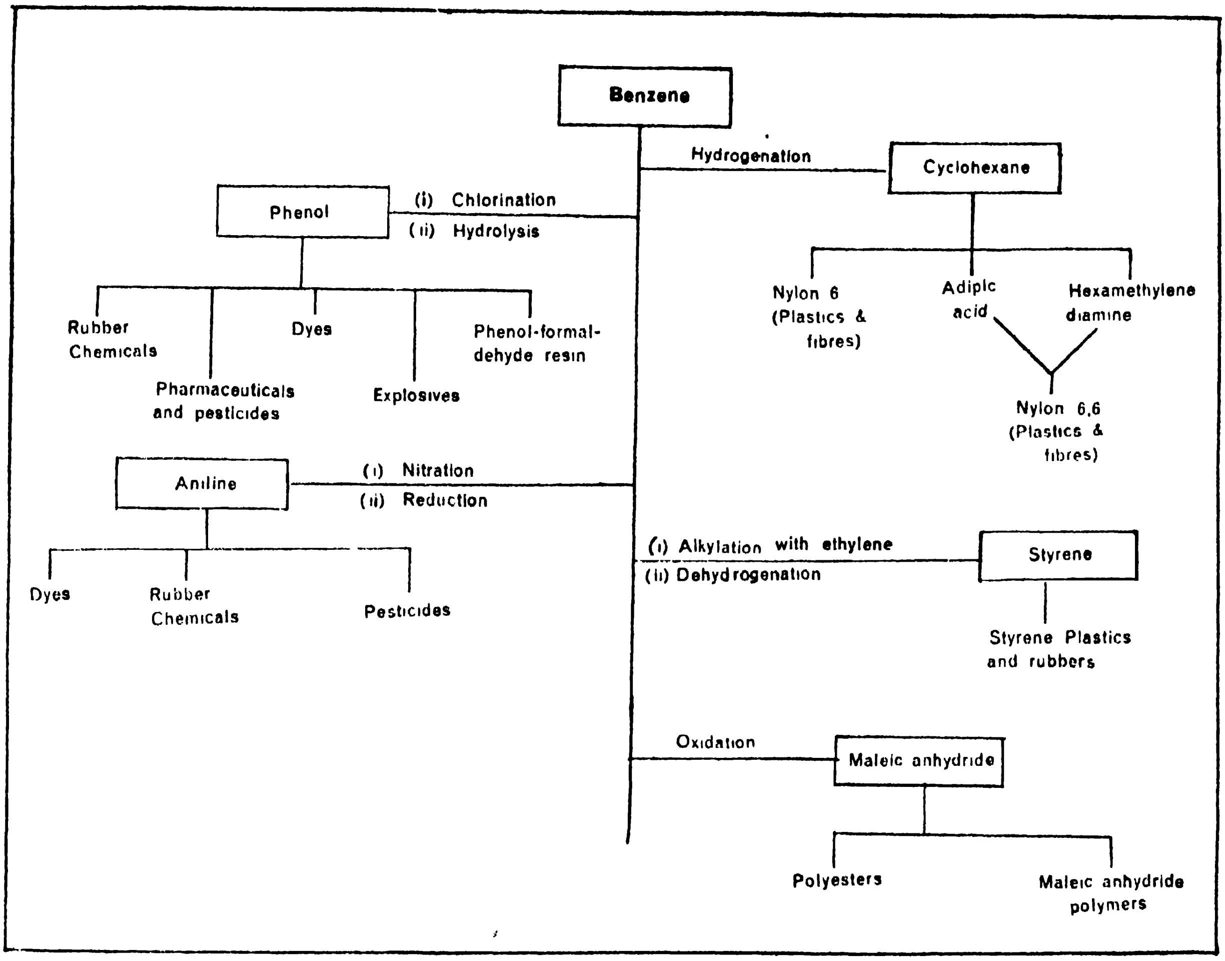

Fig. 4. Chemicals from benzene

Cracking of heavy feedstocks involves higher cost of olefin production. This factor coupled with the higher price of crude oil makes petrochemicals costlier and eventually the petrochemicals may not appear attractive as substitutes to many natural materials as before.

To counterbalance the growing cost of olefin generation, research and development efforts have already been directed to use paraffins (i.e., methane, ethane, propane and butanes) as the basic raw materials for petrochemicals in place of olefins. Recently acrylonitrile, the monomer for acrylic fibres, has been reported to be produced from propane instead of propylene. Another important monomer, vinyl chloride, may be obtained from ethane. Similarly butanes have been used as the feedstock for maleic anhydride and butadiene production. Thus the recent trends in petrochemical technology make us optimistic about the future of petrochemicals industry which seems to survive the shock of the crude oil price hike and the scarcity of naphtha.

Further reading

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HYDROGEN BONDING IN SOLIDS

A.N. GARG

Of the two types of hydrogen bond, weaker and stronger, the former (electrovalent) is often called the hydrogen bond to distinguish it from the latter (presumably covalent)

IN 1920, while describing the structure of water, the American scientists W.M. Latimer and W.H. Rodebush laid down the foundation of hydrogen bonding in following words—"Water....shows tendencies both to add and give up hydrogen, which are nearly balanced. Then....a free pair of electrons in one water molecule might be able to exert sufficient force on a hydrogen held by a pair of electrons on another water molecule to bind the two molecules together.... Such an explanation amounts to saying that the hydrogen held between two octets constitutes a weak bond."

In hydrogen bonding a single hydrogen atom appears to be bonded to two distinct electronegative atoms in a configuration represented as X—H....Y. In most cases of hydrogen bonding, one of the two bonds formed by hydrogen is much stronger than the other. The weaker of the two bonds (shown as dotted line in the above representation) is often called the hydrogen bond to distinguish it from the stronger (presumably covalent) bond. The energy of hydrogen bond is of the order of 3-8 kcal/mole compared to that of ordinary chemical bond, i.e., 50-100 kcal/mole.

The most common hydrogen bond groups are F-H, O-H and N-H. Although Cl-H, S-H and P-H also form hydrogen bonds in some situations, they are much weaker. High electronegativity of the heavy atom, leading to an acidic hydrogen, is of great importance. Thus availability of a lone pair of electrons is a good criterion for selecting acceptor atoms for hydrogen bond formation. Since hydroxyl (-OH) and amino ($-NH_2$) groups are of common occurrence in biological systems, they show hydrogen bonding quite frequently.

The widest general class of hydrogen bonding involves association of two molecules of the same or of different substances. The resulting hydrogen-bonded species need not be just dimeric but polymeric arrangements also occur in liquid H_2O, liquid HF, alcohols, proteins and inorganic materials. Broadly speaking, hydrogen bonds may be classified as intermolecular and intramolecular. Intermolecular hydrogen bonds may produce chains, rings, three-dimensional networks or even spirals in liquids or solids. The other class contains substances in which hydrogen bonds are within a single molecule. According to another classification, hydrogen bonds could be classified as symmetrical and unsymmetrical. In symmetrical hydrogen bonding, hydrogen atom is located centrally in between the two electronegative atoms X and Y so that the two bonds are of equal strength and size, e.g., in HF^{2-} ion. In unsymmetrical hydrogen bonding the hydrogen atom is nearer to one of the atoms, for example, in ice.

Detection of H bond

The formation of hydrogen bond induces many physical and a few chemical properties in molecular species. Several classical and modern methods based on these properties have been employed for the detection of hydrogen bonds. Although hydrogen bonds were first detected by solubility studies, other physical methods were soon available, for example, vapour pressure and vapour density, molecular weight, dielectric

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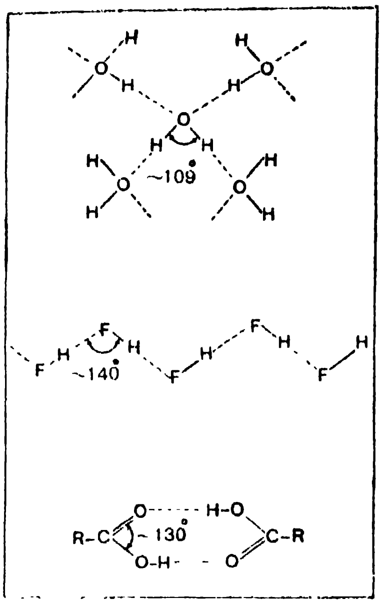

Fig. 1. Intermolecular hydrogen bonding; *Top*: Structure of water showing tetrahedral coordination around each oxygen atom, *Middle*: Structure of the hydrogen bonded polymer of HF, *Below*: Dimer of carboxylic acids

constant, partition or distribution coefficient, molecular volume, parachor, refractive index, electrical and thermal conductivity and accoustic behaviour methods. Spectroscopic methods such as infrared and Raman (vibrational) spectroscopy, ultraviolet and visible (electronic) spectroscopy, and nuclear magnetic resonance (NMR) are in common use. Also X-ray, neutron and electron diffraction techniques have been used to locate the position of hydrogen atoms in solids. Recently, nuclear gamma-ray resonance (Mössbauer effect) has also been suggested as an useful tool for studying certain hydrogen-bonded solids.

Amongst the various physical methods mentioned above, infrared spectroscopy is one of the best and widely used technique because of the sensitivity of the vibrational spectrum to hydrogen bond formation. Infrared spectra of a hydrogen-bonded system provides: (i) a definitive criterion for its detection, (ii) direct evidence of the role of proton in association, and (iii) a quantitative index of the physical and chemical properties. As a result, there is frequency shift in stretching and bending mode of particular vibration and change in half-width and intensity of the absorption bands. At the same time new absorption bands also appear because of new vibrational modes. One of the advantages of this technique is that it is applicable to all the states of matter, e.g., solids, liquids, solutions and gases of organic as well as inorganic compounds.

Ultraviolet and visible spectra also provide useful information about hydrogen bond formation due to shift in $n\rightarrow\pi^*$ and $\pi\rightarrow\pi^*$ transitions towards higher or lower frequencies, respectively. These shifts correspond usually to the energy of hydrogen bond. Since NMR studies of organic molecules have been used as a diagnostic tool for probing the molecular structure, this technique has been exploited for studying hydrogen bond formation. X-ray diffraction studies provide maximum information about the structure of a molecule and hence the position of hydrogen bonds in a solid could be predicted. But X-rays seldom allow hydrogen atoms to be located with any accuracy because of their low scattering ability. Therefore, neutron diffraction measurements on substances whose X-ray structure is known, can locate the position of hydrogen atoms with much more certainty.

Most of the theories put forward to account for the existence of hydrogen bonds are not adequate enough to explain their exact nature because of their qualitative predictive nature. According to electrostatic model proposed by Linus Pauling (U.S.A.) in 1928, the hydrogen atom with its single 1 *s* orbital cannot form more than one pure covalent bond. Therefore, hydrogen bond formation should be due to ionic forces

$$\overset{\delta-}{X}\text{————}\overset{\delta+}{H}\ldots\ldots\ldots\ldots\overset{\delta-}{Y}$$

As a result of covalent bond formation between a highly polarizable X-H group, a strong dipole is produced with X as the negative end $(\overset{\delta-}{X}\text{——}\overset{\delta+}{H})$. Now if a second electronegative atom Y, attached to another molecule with its negative end of a dipole approaches, these two dipoles come closer together because of electrostatic attraction. The closer the Y approaches H, the stronger is the electrostatic link between them.

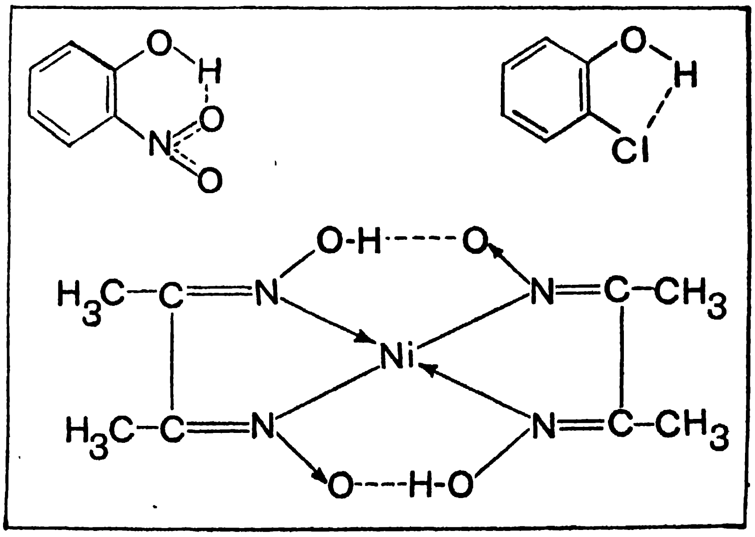

Fig. 2. Intramolecular hydrogen bonding; *Top Left*: Structure of *o*-nitrophenol, *Top Right*: Structure of *o*-chlorophenol, *Bottom*: Structure of nickel dimethylglyoxime complex

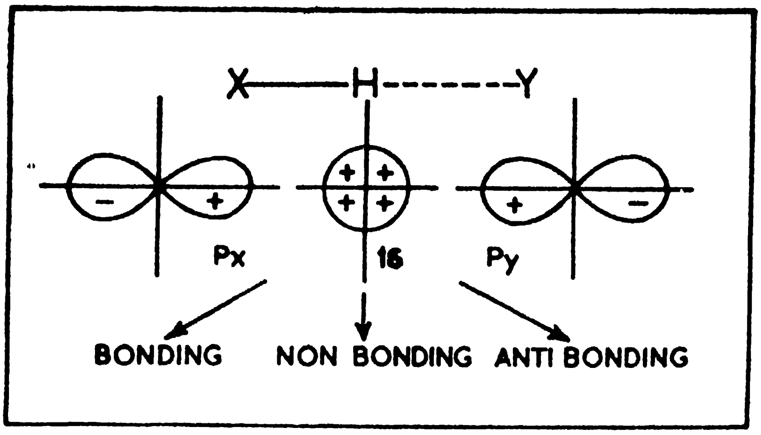

Fig. 3. Combination of atomic orbitals to form molecular orbitals in hydrogen bond formation

It has been observed that much stronger bonds are formed when X and Y are highly electronegative. For example, polymeric HF forms the most strong hydrogen bond. However, the presence of a lone pair of electrons on the electronegative atom plays an important role in determining the strength and direction of hydrogen bonds.

In 1951, the American scientist G.C. Pimental gave a molecular orbital description of the hydrogen bond. According to this approach, molecular orbitals are composed of linear combination of atomic orbitals. Using only two *p*-orbitals of electronegative atoms (X and Y), directed along the internuclear bond axis (P_x and P_y) and 1 *s*-orbital of hydrogen atom, three molecular orbitals are formed—bonding, non-bonding and antibonding (Fig. 3). Since the formation of hydrogen bond involves four electrons, they are occupied within bonding and non-bonding orbitals (two in each orbital according to Pauli's exclusion principle). However, the atoms X and Y should have the comparable electronegativity.

According to another model proposed by the English scientist C.A. Coulson (1957), one should take into consideration various energy contributions for estimating the energy of hydrogen bond. For example, he calculated the energy of hydrogen bond in ice by considering four contributions—electrostatic, delocalization, repulsive overlap of charge clouds on non-bonded atoms, and London dispersion forces. A satisfactory agreement was found between experimental bond energy and the calculated energy. This model could not be applied to other systems due to certain limitations.

Importance of H bonding

The importance of hydrogen bonding in solids, liquids or gases cannot be overemphasized. It plays an important role in determining crystal structure. Its importance was first realized while studying the structure of ice. There are in all nine crystalline forms of ice. X-ray diffraction studies suggest that in cubic form of ice each oxygen atom is surrounded tetrahedrally by four other oxygen atoms (Fig. 4) at a distance of 2.76 Å, giving an open structure which owes its stability to hydrogen bonding. When ice melts some of the hydrogen bonds are broken permitting the structure to collapse, causing a decrease in volume and increase in density.

In most of the inorganic salts involving water of crystallization, water molecules are invariably hydrogen-bonded. Often hydrogen bonding is between anions of oxyacids and water molecules. Sometimes it also occurs between different water molecules in the structure. For example, ferrous fluorosilicate hexahydrate $FeSiF_6 . 6H_2O$, magnesium sulphate tetrahydrate $MgSO_4.4H_2O$, barium chloride dihydrate $BaCl_2 . 2H_2O$, copper sulphate pentahydrate $CuSO_4 . 5H_2O$, uranyl nitrate hexahydrate $UO_2 (NO_3)_2 . 6H_2O$, calcium sulphate dihydrate $CaSO_4 . 2H_2O$ and potassium ferrocyanide trihydrate $K_4Fe(CN)_6 . 3H_2O$ contain hydrogen-bonded water molecules. Even some organic crystalline hydrates like that of violuric acid,

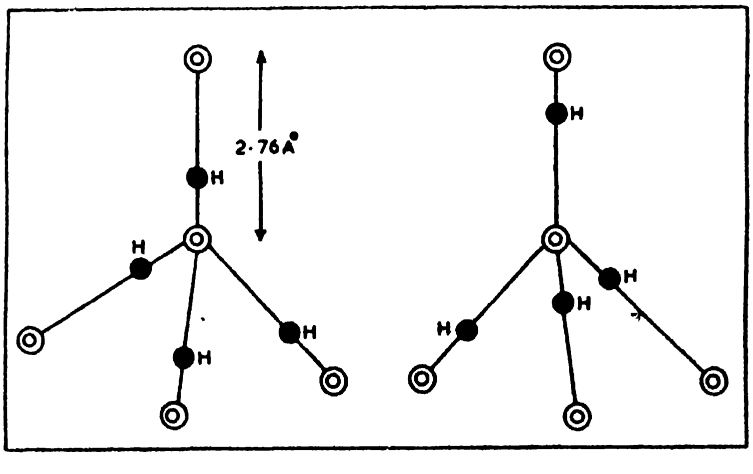

Fig. 4. Two possible configurations showing hydrogen and oxygen atoms in ice

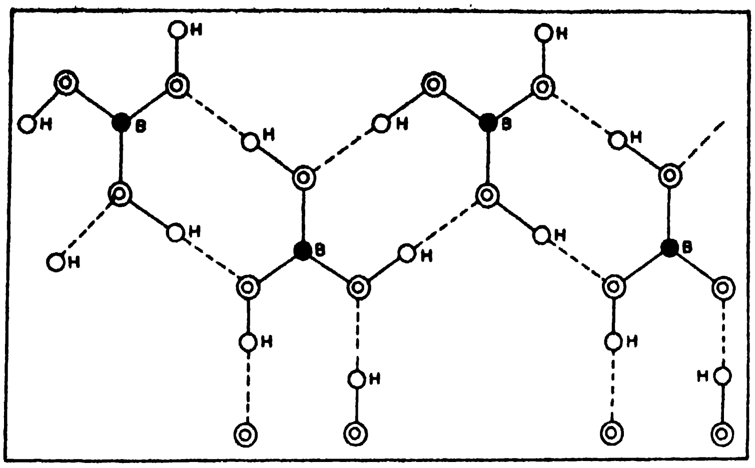

Fig. 5. Structure of orthoboric acid showing hydrogen bonds

oxalic acid and some salts like sodium perxenate, potassium oxalate and potassium hydrogen phenylacetate are all hydrogen bonded.

Next to water, ammonia and ammonium salts form most important hydrogen bonding entity in inorganic compounds. The ammonium ion is capable of making four hydrogen bonds by contributing hydrogen atoms. Single crystal X-ray and neutron diffraction studies indicate that solid NH_3 forms most simple and ordered hydrogen-bonded structures. All the three ammonium halides, NH_4Cl, NH_4Br and NH_4I, ammonium hexafluorosilicate $(NH_4)_2SiF_6$ and ammonium perchlorate are all hydrogen bonded by way of ammonium ions.

In crystalline $NaHCO_3$ there are four kinds of O-O distances having values 2.55, 3.12, 3.15 and 3.19 A°; the last three being approximately equal to twice the van der Waals' radius of oxygen atom, and the first (2.55 A°) corresponds to the unsymmetrical hydrogen-bonded pair O-H....O. Similarly, the structure of orthoboric acid H_3BO_3 was found to consist of loosly bound parallel sheets of hydrogen bonded units as shown in Fig. 5. Similar confirmation for the same type of hydrogen bonding has been obtained for the crystals of KH_2PO_4 and $Ag_2H_3IO_6$.

Recently it has been established that under limited conditions Mössbauer spectroscopy could also be used to investigate the presence of hydrogen bonding. It was already known from infrared and other techniques that $H_4Fe(CN)_6$ and $H_3Fe(CN)_6$ are intermolecularly unsymmetrical hydrogen bonded via N-H....N. Now it has been shown conclusively by Mössbauer spectroscopic evidence that there is an observable change in the behaviour of these compounds compared to their alkali metal salts where there is no possibility of hydrogen bonding.

The importance of hydrogen bonding lies not only in determining the structure of a solid but many a times in the study of other states of that substance.

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ACTIVATION ANALYSIS

SUMAN AGARWAL

The technique finds a number of applications due to its high sensitivity, non-destructive nature and rapidity

As we know, every element is composed basically of neutrons and protons at the nucleus which is surrounded by electrons. The properties of an element depend on its atomic number (Z), i.e., the number of protons at the nucleus. The protons are positively charged and this charge is balanced by an equal number of negatively charged electrons. The weight of an atom is expressed as the total number of neutrons and protons. Sometimes in two different nuclei, the number of protons is the same but the number of neutrons differs. In this case, other properties remaining same, their atomic weights differ and the two nuclei are called isotopes. But all the elements have some prefered composition at which they are most stable and that is why we cannot have as many isotopes of an element as we like. If we introduce some particle, neutron, for example, by force into an atom, this atom will try to rearrange itself and in this process it may give out some particles which may as well appear as energy. This process is called artificial radioactivity. There is another way of rearrangement in which atom may break up in two or more fragments, viz., fission. So the number of protons and neutrons at the stable state is very much limited and, whenever it is crossed, radio-activity originates.

This may however be better understood with the help of stability diagram (Fig 1). The compositions which fall on stability line are the most stable ones. If by artificial means we convert one neutron into a proton, the element will have number of protons equal to $Z+1$ and neutrons $N-1$. That is to say, the position of the element in the diagram will be shifted towards one place down to the right. So the composition which lies on the left of the stability diagram will try to convert one of its neutrons into a proton, i.e., it will radiate β^- rays and shift over to the right where it will find itself much nearer to the stability diagram. With similar arguments we can say that the compositions lying to the right of the diagram will probably emit positive electrons. It is seen therefore that more an element goes away from the diagram the more unstable it becomes and it is more difficult to detect it. By artificial radioactivity it has been possible to detect about 1800 isotopes of all the known elements. The physicists, however, think that some 2500 more artificial isotopes can be produced.

How to activate a stable element? The nucleons (protons and neutrons) in an atom are bonded with certain energy which is called bonding energy. A nucleus can be activated by various methods depending on the nucleus and our need. We can have a nucleus bombarded with neutral particles like neutrons or γ rays, charged particles like α rays (which can be represented as a He atom, He^{4}_{2}) or with β^- rays which can be considered as negatively charged electrons. With the help of various accelerators which can increase the velocity and thus the energy of a projectile, it has become possible to bombard different atoms with high energy ions also as, for example, with carbon, nitrogen or neon ions. Using these methods it has been possible to synthesise the transuranium elements like $Z=99$ (Einsteinium), 100 (Fermium), 104 (Kurchotovium), etc. One such example is given below:

$$^{242}_{94}Pu + ^{22}_{10}Ne \longrightarrow ^{260}_{104}Ku + 4n$$

For activation analysis the most simple reactions involving bombard-

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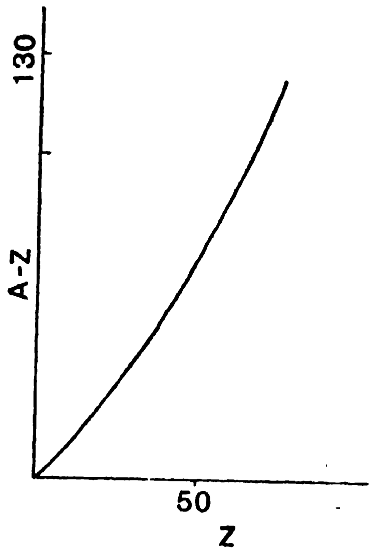

Fig. 1. Stability diagram

ment of neutrons are the neutron capture reactions. For example, if we bombard aluminium with neutrons, it will absorb neutrons and by rearranging its internal structure gives out γ rays. This can be shown as follows:

$$^{27}_{13}\mathrm{Al} + {}^{1}_{0}\mathrm{n} \longrightarrow {}^{28}_{13}\mathrm{Al}^{*} + \gamma$$

or $$^{27}_{13}\mathrm{Al}\left({}^{1}_{0}\mathrm{n}, \gamma\right){}^{28}_{13}\mathrm{Al}^{*}$$

[Star (*) signifies that the atom is radioactive]

$^{28}_{13}$Al* has half-life period of 2.3 min and disintegrates emitting β^- and γ rays into a stable silicon nucleus,

$$^{28}_{13}\mathrm{Al}^{*} \longrightarrow {}^{28}_{14}\mathrm{Si} + \beta^{-} + \gamma$$

The wide use of nuclear reactions for the analysis of chemical elements was indicated by Frederic and Joliot Curie. They bombarded aluminium-27 by α-particles and treated the resultant with HCl. They found that a few molecules (10^{-5} to 10^{-20} molar quantity) of PH_3 are formed which could be detected by the counter. Thus by employing artificial activation analysis of the trace materials is possible. In activation analysis advantage of the characteristic nuclear properties of an element is taken. It is found that the detectable properties of an activated product depend on (a) period of irradiation of the sample, (b) cross-section of a reaction, (c) the nature of the incident particle, and (d) the energy of the incident particle.

Period of irradiation of the sample

Different elements have different saturation time of irradiation. If one does not activate an element to its saturation, the activity produced will only coincide with the period for which it was irradiated. Suppose an element X has a saturation period of one month and another element Y has that of three minutes only. If we irradiate the mixture of these two elements for three minutes, the second one will be fully activated whereas the first one will, almost, not be activated at all. So by proper selection of the period of irradiation we can avoid activation of unwanted elements.

Cross-section of a reaction

Cross-section of a reaction can be defined as the area available for a single particle to react. It is connected with the probability of a particular reaction taking place (i.e., probability of absorption of a particular particle). Probability of an interaction is given by the equation:

$$P = nI\sigma$$

where I is the number of incident particles on the target per second, having n atoms/cm^2, and σ is the cross-section. So we can define σ as the probability of interaction if there is only one particle bombarded per second on a target having only one atom. For various types of interaction σ depends on various other factors also, e.g., for the absorption of neutrons $\sigma \propto \frac{1}{v}$, i.e., less the velocity more is the probbability of getting the neutron absorbed in the target. Its value 10^{-24} cm^2 is defined as one barn. Cross-sections of capture of slow neutrons for some of the isotopes are given below:

^{50}Cr	16 barns
^{52}Cr	0.8 ,,
^{53}Cr	18 ,,
^{54}Cr	0.37 ,,
^{94}Fe	2.2 ,,
^{96}Fe	2.6 ,,
^{58}Fe	0.9 ,,
^{59}Mn	13.3 ,,
^{60}Co	100 ,,

It is seen above that σ varies even for different isotopes of one element and due to this reason one can detect or analyse different isotopes of one element in one sample.

Nature of the incident particle

It is natural that if one element is irradiated with two different particles two different products will be obtained. For example, if Al is irradiated with 6–10 Mev neutrons, we get the product according to the following reaction:

$$^{27}_{13}\mathrm{Al}\ (\mathrm{n},2\mathrm{n})\ {}^{26}_{13}\mathrm{Al}$$

and if it is irradiated with α-particles we get:

$$^{27}_{13}\mathrm{Al}\ (\alpha,\mathrm{n})\ {}^{30}_{15}\mathrm{P}$$

Energy of the incident particle

Similarly for different energies of the incident particle we get different products. Taking the same element we see that if ^{27}Al is irradiated with thermal neutrons, that is, the slowed down neutrons having energy round about 0.025 Mev, we get excited aluminium atom radiating β^- and γ rays. But if it is irradiated with neutrons of much higher energy, i.e., a few Mev, we get the following two reactions:

$$^{27}_{13}\mathrm{Al}\ (\mathrm{n}, \alpha)\ {}^{24}_{11}\mathrm{Na}^{*}$$

$$^{27}_{13}\mathrm{Al}\ (\mathrm{n}, \mathrm{p})\ {}^{27}_{12}\mathrm{Mg}$$

Let us see how can we find out the unknown elements quantitatively. If we have a reaction of the type A→B*→C (stable), then we can write

$$\triangle N_{B}^{*} = N_{A}.\sigma_{AB}\O dt$$

where $\triangle N_{B}^{*}$ is the number of nucleus B created in the time interval t and $t+dt$ per second. N_A is the number of nuclei A exposed to irradiation, σ_{AB} is the cross-section of reaction A→B*. Ø is the flux of incident particles per cm^2 per sec.

In the interval t and $t+dt$ some of the $\triangle N_{B}^{*}$ will be destroyed because B* is radioactive. If this number is represented by $\triangle N_{Bt}$ then we can write

$$\triangle N_{Bt} = \lambda_B \, N_{Bt} dt$$

where N_{Bt} is the number of B* after the irradiation of the sample for the time t. So the increase in radioactive atoms N_{Bt} will be given as

$$N_{Bt} = \frac{N_A \sigma_{AB} \phi}{\lambda_B} \left(1 - e^{-\lambda_{Bt}}\right)$$

Radioactivity is expressed as the product of activity constant and the population, i.e., $N_{Bt}.\lambda_B$

$A(t)$ (radioactivity) =

$$N_A \sigma_{AB} \, \phi \left(1 - e^{-\lambda_{Bt}}\right)$$

If we carry out the same experiment for a known quantity of the elements under the same conditions, comparing the two results we get,

$$A(t)/A'(t) = N_A/N'_A$$

where the primes (′) express the values for the known set.

If f_A is the fraction of impurity in the sample, m the mass of the sample, N^0 is Avogadro's number and A the atomic weight, then

$$N_A = f_A.m.N^0/A$$

$$\text{or } A(t) = f_A . \frac{N^0 . m . \phi . \sigma_{AB}}{A} \left(1 - e^{-\lambda_{Bt}}\right)$$

So from this equation we can calculate the absolute activity of any activated product.

Let us take a typical example, estimation of impurity of Cu in aluminium. This can be done in the following steps.

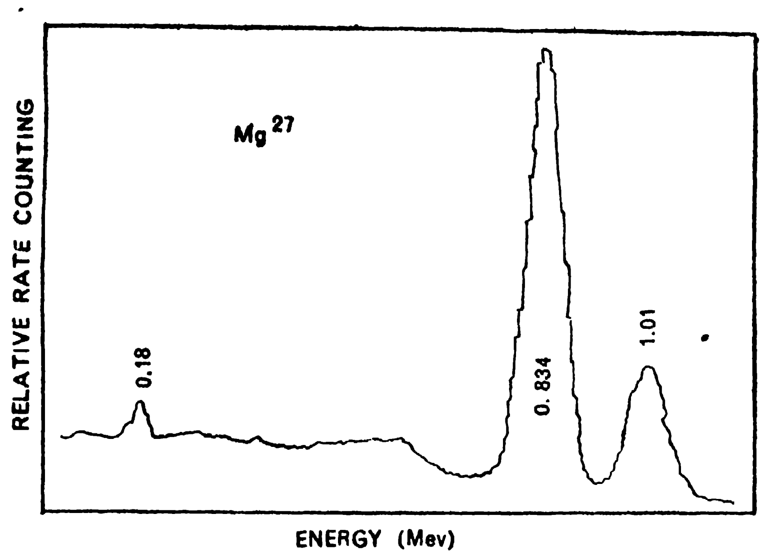

Fig. 2. A typical example of X-ray spectra

1. About 1gm of the sample to be analysed and standard sample containing known quantity of Cu are placed side by side in a polythene tube and irradiated with thermal neutrons in the reactor. There are two stable isotopes of Cu in nature and generally we find them together. The reactions taking place are as follows:

$$^{63}_{29}\text{Cu}\,(\text{n}, \gamma)\ ^{64}_{29}\text{Cu}^{*} \quad 12.8 \text{ h}$$

$$^{65}_{29}\text{Cu}\,(\text{n}, \gamma)\ ^{66}_{29}\text{Cu}^{*} \quad 5.1 \text{ m}$$

The quantity of radioisotopes formed will depend on the time of irradiation, the flux of neutrons, the fraction of the isotopes of Cu present in Al, their atomic weight and finally the reaction cross-section.

2. The isolation of Cu can be done as follows. A known quantity of pure natural Cu is added to both the samples so that the chemical separation of Cu from aluminium becomes easy. Both the samples are dissolved in 6N HCl and precipitated as the second group metals by H_2S. This process can be repeated to avoid the impurities due to co-precipitation of other group metals.

3. Now to separate Cu from other second group metals, a few milligrams of each of the metals of second group are added after dissolving the precipitate and the Cu is separated by selective precipitation with thiocyanate. The process is repeated to get rid of the co-precipitated elements. Since the process and other conditions are kept same for both the samples, we can find out the Cu content in the unknown sample simply by comparing the γ-ray activity in the samples.

Since $^{64}_{29}$Cu radiates γ-rays of energy 1.34 Mev and $^{66}_{29}$Cu that of 1.04 Mev and 0.83 Mev, we can take γ spectra and seeing the areas under the peaks and comparing them with the standard we can say whether the separation is radiochemically pure or not. Thus fifteen elements of rare earth group are separated in a single operation of chromatography on rasin. Since their properties are very near to each other, it is difficult to separate them by classical methods.

However, for analytical purposes this chemical separation is necessary only when other elements alongwith the elements of interest are also activated or when two or more elements have peaks in the same region. In other cases one can, naturally, analyse the elements without chemical separation also. In fact, now-a-days γ-spectroscopy is very much used for analysis without chemical separation. Since the energies of the radiating γ-rays are different for most of the elements, we get separate peak for each element which can be identified by calculating corresponding energy.

In this method the risk of pollution is very little. Also the importance of this method lies in its non-destructive nature in most of the cases. As for example, if Al, Mn or V are irradiated with slow neutrons, they form radioelements which are inactive in few minutes or a few hours only. However, there are two possibilities of error. In most of the cases the slow neutrons are accompanied by some fast neutrons which give rise to the same radioisotope for two different irradiated elements causing a problem.

$$^{23}_{11}\text{Na (n (slow)}, \gamma)\ ^{24}_{11}\text{Na}^*$$

$$^{27}_{13}\text{Al (n (fast)}, \gamma)\ ^{24}_{11}\text{Na}^*$$

An element formed after irradiation may coincide with the element under investigation. One such example is given below:

$$^{75}\text{As (n}, \gamma)\ ^{76}\text{As}^*$$

$$^{76}\text{Ge (n}, \gamma)\ ^{75}\text{Ge}^* \rightarrow\ ^{75}\text{As} + \beta^-$$

This causes the increase in quantity of ^{75}As.

The activation analysis may also be used to find trace impurities in semiconductors, detect trace elements in plant tissues, and in forensic science.

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MAGNETIC BUBBLES

(Continued from page 524)

Bobeck, Thiele and others at Bell Telephone Laboratories was first published in 1967, only seven years ago. Today, the major electronic manufacturers in the USA and Japan are planning to market bubble domain devices before the end of this decade. The memory technologists are thrilled at the prospect of having a faster computer memory without any moving parts and the possibility of performing both memory and logic functions on the same piece of material. The added advantages of bubble devices are their low power requirement and durability against massive dosage of nuclear radiations. In contrast, the performance of semiconductor devices is highly susceptible to radiation. This makes the bubble devices the logical choice for space electronics.

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TISSUE CULTURE

(Continued from page 541)

carbohydrate metabolism and active transport.

Finally, a word of caution! It should be made sure that cell culture is free from contamination with mycoplasma and latent viruses. Because, if present, they interfere with the results of experiment and the purpose of experiment would get defeated.

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TISSUE CULTURE IN BIOLOGY

S.M. GOYAL AND I.P. SINGH

Tissue cultures are employed to investigate functional activities of differentiated tissues *in vitro* for quantitative nutrition and metabolism studies and in the virus research

THE growth of isolated cells, organs and tissue segments in an artificial environment outside the parent organism is called "tissue culture". It involves removal of tissues and incubating them in an environment conducive to their growth. Thus their morphological, physiological and biological changes can be observed during growth and differentiation. Tissue culture techniques can now be used in any laboratory and have become almost indispensible in the fields of physiology, genetics, bacteriology, virology, parasitology, pathology, entomology, embryology, biochemistry, pharmacology, radiology, zoology and medicine.

History

The first successful explantation of living tissues was done by the German botanist William Roux in 1885. He isolated the medullary plate of a chick embryo and kept it alive in a warm physiological solution. The feat of keeping the tissues alive outside the body was repeated by several workers but the first successful tissue culture, in the modern sense, was performed by an American scientist Ross Harrison in 1907. He explanted small pieces of tissue from the medullary tube region of frog embryo into frog's lymph. When kept under aseptic conditions, the fragments survived for some weeks and the nerve fibres grew out from the cells. However, it remained for Alexis Carrel (1912), the Nobel prize winning American surgeon, to demonstrate that animal cells could be grown indefinitely *in vitro*. Upto this time, the cells were grown on clots of lymph or plasma. Wilton R. Earle and his colleagues at the National Cancer Institute, Bethesda, Maryland, USA were the first to grow cells directly on glass, the first to grow cultures from single cells and to propagate cells intentionally in suspension. The technique of organ culture, which has yielded a great deal of important information in embryogenesis and endocrinology, was developed in 1920's by T.S.P. Strangeways and Honor B. Fell at Cambridge, U.K. The real impetus to tissue culture was given by J.F. Enders and his associates (1949) at the Harvard Medical School, Boston, USA when they were able to grow poliomyelitis virus in cell culture of non-neural origin.

Types of tissue culture

The essential operations for successful tissue culture involve: (a) removal of viable cells from their normal environment; (b) proper explantation of those cells onto a suitable substrate; and (c) the subsequent nourishment of the cells by a nutrient medium. These requirements are fulfilled by any of the three types of cultures now in use: (a) cell monolayer cultures—in which cells grow on a glass or polystyrene surface, approximately one cell-layer deep; (b) organ cultures—in which functional "cell groups" are maintained *in vitro;* and (c) suspension cultures—in which cells grow in a dispersed state in a fluid medium. The choice of technique used depends on the need of the investigator.

Monolayer culture. A monolayer culture is a sheet of contiguous cells growing on a glass, cellophane or a

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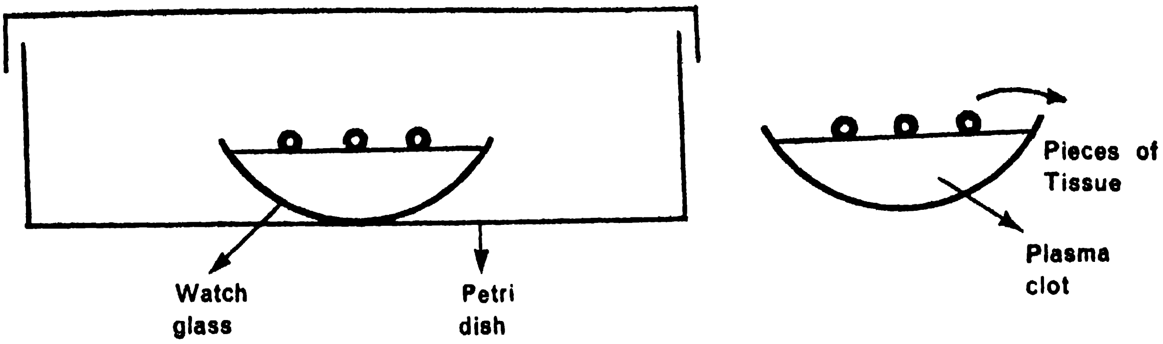

Fig. 1. Watch glass technique of organ culture (schematic diagram)

similar substrate. The proper name for such type of culture is "cell culture" and has extensively been used in virus research. Cell cultures are primarily intended for the study of growth and for this purpose diffusely distributed cells in constant active proliferation are desirable. Cell cultures are of two types; the established cell lines and primary cell cultures.

Primary cell culture involves cells isolated from an animal source and grown in a single passage or sometimes two passages in artificial media. (The term "passage" is synonymous with "subculture" and denotes the passage of cells from one culture vessel to another). These cultures are prepared by disaggregation technique in which the tissue is removed from an animal and disaggregated, usually by treatment with a proteolytic enzyme such as trypsin, to give a dispersed suspension of viable cells. These cells are then suspended in the nutrient medium and introduced into the culture vessels (flat-bottom bottles or test tubes). The cells attach to the glass, flatten and multiply to form a continuous sheet, usually one cell thick. The cells in culture dedifferentiate, i.e., they lose their highly specialised functions. The cells exhibit the phenomenon of contact inhibition by virtue of which the normal cells (cells which are not cancerous), when in contact with each other, are immediately immobilized resulting in the cells lining up in strongly oriented parallel strands. This is the reason for their forming a monolayer.

Established cell lines, also known as permanent cell lines, are derived usually by one of the two methods: (a) by serial passage of the cells under study, and (b) by producing clones from suitable primary cultures. In a declining primary cell culture, foci of rapidly growing cells appear suddenly. They increase quickly and soon outgrow the other cells and can usually be cultivated indefinitely. This process is called "transformation".

The established cell lines are characterized by a steady rate of growth over long periods and are usually somewhat bizarre karyotype. They have certain advantages over the primary cell cultures, namely, uniformity of cell type, ease and convenience of handling, and availability of the same cell strain to different investigators.

Organ cultures. To investigate the functional activities of differentiated tissues *in vitro*, organ culture techniques are employed. Tissues are grown under conditions which allow maintenance of already differentiated structures or permit partially differentiated tissues to develop. The tissues are explanted in such a way so that minimal cellular migration and limited mitosis take place.

For several years, tissue slices in simple media were utilized for studying the metabolic and enzymatic activities of cells. But this approach is limited by the brevity of the experimental period which is about an hour or so. The "watch glass" technique of the British scientists Strangeways and Fells is a simple method of organ culture. It consists of placing an explant on a plasma coagulum in a 3.7 cm watch glass, which in turn, is mounted in a 7.5 cm petri-dish containing a moistened pad of cotton or blotting paper to prevent evaporation (Fig. 1). Cultures of this kind survive for a longer period of time and are mainly used in embryology, oncology and pharmacology, and to a lesser extent in virus research.

Suspension cultures. This system permits active proliferation of mammalian cells as individual units suspended or submerged in a liquid medium. The nutrient medium in this case is in constant agitation so as to prevent the cells from settling onto the glass surface or aggregating into clumps. This technique is mostly applied for cell strains and is particularly well suited to nutrition, metabolism and population studies.

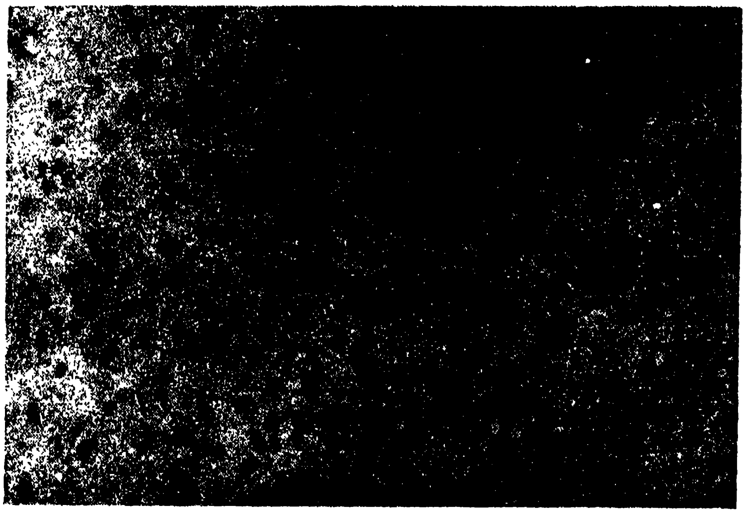

Fig. 2. Normal lamb testicular cells 144 hours after seeding

Environment of cells

Various environmental factors affecting tissue culture are temperature, hydrogen ion concentration and osmotic pressure. The mammalian cells can grow at 37° to 38.5 °C but the optimum temperature is 37.5 °C. Most cells are killed at 45°C within an hour but they survive in low temperature to a considerable extent. In fact, the preservation of cells is achieved by storing them in deep freeze at — 70 °C or even at — 183 °C. At 38 °C, the normal osmotic pressure is about 7.6 atmospheres. The range of pH at which cells can be grown is from 6.6 to 7.8 with an optimum at 7.2 to 7.4. The cells in culture require sodium, potassium, calcium, magnesium, iron, carbonate and phosphate ions. The function of some of these ions is not known. Others are required for maintenance of osmotic pressure, functioning of certain intracellular enzymes and spreading of cells on glass. In addition, oxygen and carbon dioxide are also essential for cell survival.

Nutrition

The nutritional requirements and metabolic activities of cells in culture are essentially similar for all cell lines, regardless of the species or tissue of origin. This greatly simplifies the techniques for growth of cells *in vitro*. Cellular metabolism and growth can be maintained indefinitely provided adequate nutrition is available to the cells. A source of carbohydrate is essential for cultured cells and usually glucose is used for this purpose. In addition to the so-called essential amino acids for mammals, the cells in culture require cystine, tyrosine and glutamine. Several vitamins of 'B' group form a part of co-enzymes involved in metabolism and hence in cell growth and multiplication. Proteins and peptides are also essential for cell growth. The nutritional and environmental requirements of cells are met with by the use of nutrient media.

Nutrient media

The medium is by far the most important single factor in culturing cells and tissues. The basic components of cell culture media are:

(a) A balanced salt solution which provides essential inorganic ions and maintains osmotic pressure and pH within narrow limits of variation. Many balanced salt solutions are available such as Tyrode, Ringer, Locke, Lewis, Drew, White, Harris, F_3, and Smith solutions. However Hanks, Gey and Earle's solutions are most commonly used.

(b) A nitrogen source, e.g., yeast extract or lactalbumin hydrolysate or both.

(c) Biological additives such as serum, chicken plasma, chicken embryo extract or amniotic fluid.

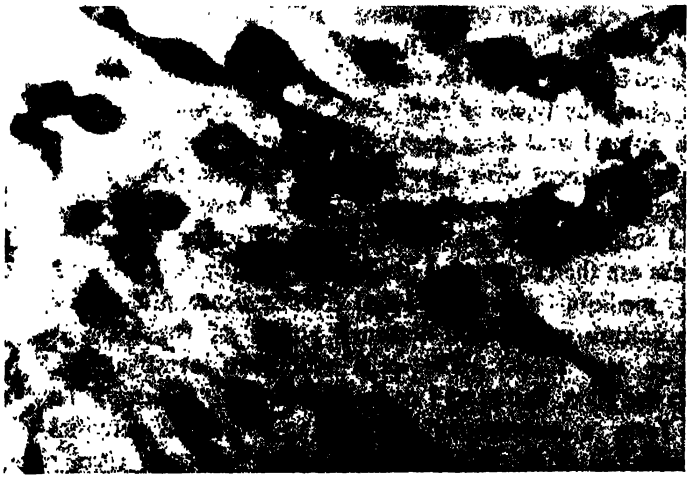

Fig. 3. Lamb testicular cells 96 hours after infection with sheeppox virus. Note inclusion bodies surrounded by clear halo (arrows)

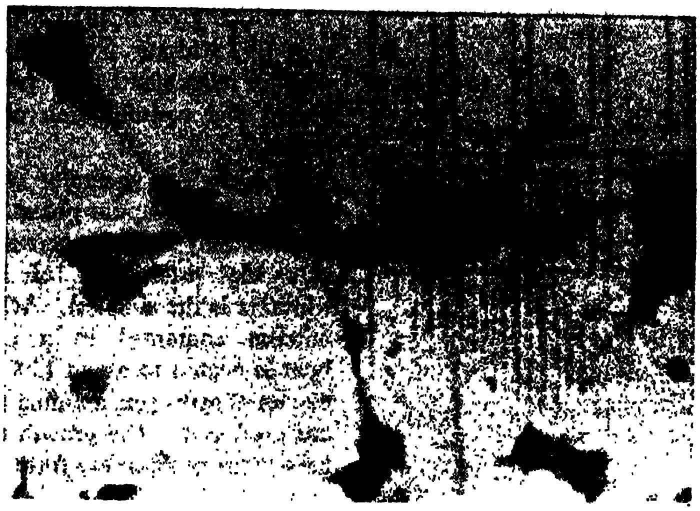

Fig. 4. Lamb testicular cells 168 hours after infection with sheeppox virus. Complete degeneration of cell sheet

(d) Antibiotics to ensure bacteriological and mycological sterility.

In addition to the non-defined media mentioned above, considerable progress has been made towards the evolvement of chemically defined media. However, defined media are suitable only to a particular cell strain and are primarily used as maintenance media. Many formulations have been proposed, viz., medium no. 199, medium no. 858, medium no. NCTC 109 and Eagle's medium, to mention a few.

Applications of tissue culture

Progress in medical science depends on a number of approaches and tissue culture is the one which possesses immense potentialities for tackling basic biochemical problems which have so far remained obscure. It could be gainfully used to study the metabolic aberrations of diseases, their cure and prevention, biochemistry of malnutrition, mode of action of drugs, mechanism of hormone synthesis and antibody formation, mechanism of formation of growth factors, effect of vitamins and hormones on glands and organs, and the mode of action of toxic substances at cell level. Given below is a brief outline of the applications of this tool in various sciences.

Virology. The greatest benefit of tissue culture has been to the science of virology because with the advent of tissue culture, the cultivation of viruses ceased to be a problem and also it facilitated the production of effective vaccines against many diseases of men and animals. Some of the viruses produce, in the cultured cells, certain readily visible cytological changes called the 'cytopathic effects ' (CPE) (See Figs. 2,3 and 4). These cytological changes consist of granulation of cytoplasm, nuclear changes like pyknosis, giant cell formation, syncytium formation and total degeneration of cells. This CPE is neutralized by serum containing specific antibodies. Therefore, by the use of immune sera we can identify different viruses. In addition to virus isolation and identification, tissue culture can be used for virus quantification (assay or titration of viral infectivity) by plaque technique, for viral genetics and biochemistry of viral synthesis, and for immuno-fluorescence studies.

Oncology. Sometimes the normal cell lines, after repeated cultivation, suddenly become transformed into rapidly proliferating cells with accompanying biochemical changes. Such cells resemble cancerous cells in their rate of proliferation. By studying the behaviour of such cells, some fundamental studies on the neoplastic process could be carried out, some of which are: how carcinogens are involved in neoplasia; what are the differences between a normal and a cancerous cell; what is the mechanism of metastasis; and what is the relationship between neoplastic cell and its non-neoplastic neighbours? In addition, study of oncogenic viruses and screening of antitumour agents could be carried out in tissue culture.

Animal cell nutrition. Tissue culture can be used for determining the precise nutritional and metabolic characteristics of cells, tissues and organs after isolating them from the influence of the organism as a whole because it is impossible to regulate the nutritional environment of cells in the intact organism whereas, in cell cultures, the medium can be defined very precisly.

Pharmacology. With tissue culture techniques it is possible to study how a drug is absorbed and metabolised by different cells. The pharmaceutical, bactericidal and viricidal activity of drugs can also be studied.

Bacteriology. It is possible to study phagocytosis by various macrophages, cell response to the growth of intracellular organism, and the effects of microbial toxins and products of bacterial metabolism on cell culture. Toxins and antisera are also titrated in tissue culture.

Parasitology. To grow parasites that have a facultative or obligatory intracellular phase or completely extracellular growth.

Radiology. The effect of radiations on cell growth, cellular morphology, chromosomes and cell biochemistry.

Biochemistry. Experiments on

(*Continued on page 537*)

SCIENCE SPECTRUM

Whisker composites—space age materials

THE term "whisker composite" refers to a new class of materials characterised by high strength, stiffness, low density and excellent ability to withstand high temperature. They are attractive materials of construction as their properties are in many respects superior to those of metals and alloys.

Whisker composites are made of two distinct constituents, viz., (a) unidirectionally aligned, extremely fine single crystal fibres of metal or ceramic called whisker, and (b) a soft matrix which binds the whiskers together. Whiskers have unusually high strength. In fact they are the strongest form of solid yet discovered. The prime function of whiskers in composites is to bear the externally applied load, whereas the matrix plays the role of transmitting and distributing loads to individual whiskers. Thus, in short, the purpose of incorporating whiskers in a soft matrix is to reinforce the latter.

Strength of whiskers and whisker composites

The strength of a whisker approaches the theoretical strength of a perfect solid (free from defect) which lies in the range of $0.03E$ to $0.17E$, where E is the modulus of elasticity. The dimension of a whisker is too small to contain any defect and consequently it is very strong.

Most metals and a large number of ceramic materials can be obtained in the form of whiskers. Ceramic whiskers are by far the strongest material. Besides high strength, they also have low density, relatively high modulus, and good ability to withstand high temperature and therefore are the most promising reinforcing agents in the field of composites.

The strength of the whisker composite depends on the volume fraction of whisker in the matrix. It is seen that a certain minimum volume fraction of whiskers is required for a composite strength greater than that of the matrix. Strength of a whisker composite is also a function of whisker alignment. In fact, it is one of the important steps in the fabrication of whisker composite.

Production of composites

Production of whisker composites consists of a number of steps, viz., (i) whisker growth; (ii) whisker coating; (iii) whisker beneficiation, (iv) whisker alignment; and (v) combination and consolidation of constituents.

Whiskers are generally grown by reaction in the vapour phase. Among commercially available ceramic whiskers the production of alumina whiskers is the simplest. When aluminium contained in a porcelain boat is heated to about 1300 °C in a stream of hydrogen, alumina whiskers are produced. The growth of whiskers takes place in the form of wool on the boat itself.

The major reactions involved in the process are as follows:

$$H_2 + SiO_2 (s) \rightarrow H_2O (g) + SiO (g)$$

$$4\,Al (l) + 3H_2O (g) + 3\,SiO (g) \rightarrow \underbrace{2Al_2O_3 (g)}_{\text{whisker}} + 3H_2 (g) + 3Si (l)$$

(Silica taking part in the reaction comes from the porcelain boat.)

Whiskers are prone to develop surface defects. This makes the whisker weak. Hence for protection whiskers must be coated immediately after their growth. Choice of coating material depends on the composition of the whiskers and of the matrix. It is to be so chosen that (a) it does not dissolve in the matrix, and (b) it does not react with the whisker and thereby weaken them. Alumina whiskers are normally coated with either tungsten or nickel. These coatings are applied by vapour deposition technique.

Strength of a whisker is a function of its size. Smaller the diameter of the whisker, greater is its strength. Whiskers are generally produced in the form of tangled wool containing fibres of different sizes. Finer sized whiskers are sorted out from this as only these can act as effective reinforcing agent in composites.

For alignment the whiskers are arranged unidirectionally. In a simple technique the whiskers are dispersed in a viscous medium of ammonium alginate and water. The suspension containing whisker is

Table 1. Strength of a few composites

Material			*Tensile strength in 1000 psi*
Matrix	*Whisker*	*Vf*	
Al	Al_2O_3	0.35	161
Al	—	—	12
Fe	Al_2O_3	0.36	237
Fe	—	—	41
Ag	Al_2O_3	0.24	232
Epoxy resin	Al_2O_3	0.14	113

forced through a nozzle (extruded) into a bath containing dilute acid. The bath causes the alginate suspension to transform into a gel. This action holds the aligned whiskers in place. The gelled tape is further stretched by drawing and winding onto a rotating drum. After several layers are built up on the drum, a cut is made across the drum length and the layers are flattened out to form a large sheet. The sheet is then dried and the organic binder is burned off.

Whisker-reinforced resin composite is formed by pouring molten resin in a mold containing aligned sheets of whisker. Once the resin has set, the composite is pressed and compacted to the desired whisker volume fraction by squeezing out excess resin. Resin composites containing as much as 55 per cent volume of well-aligned whiskers can be easily produced in this manner.

For the production of composite with metallic matrix the technique is slightly modified. Finely divided metal powders (viz., Ag, Ni, Fe) are incorporated in the whisker-alginate slurry before extrusion. Consequently the tape thus produced contains both metal as well as whiskers. The tape is later dried and the alginate burned off. Composites are then fabricated by hot pressing a number of these whisker/metal tapes.

Properties and uses

A look at Table 1 will reveal how strong a whisker composite can be. It might be really surprising to note that even a resin (plastic) with whisker reinforcement could be made stronger than metal. Besides strength, composites have certain other attractive properties too. They can retain their strength at high temperatures for a much longer time compared to presently available metals and alloys. Moreover as the composites contain a significant amount of light-weight whiskers, these are also characterised by low density. All these properties make whisker composites most attractive for aero-space use. In fact, they have been rightly called the "space age" material.

RABINDRA NATH GHOSH

Ion selective electrodes

AN analytical chemist is quite familiar with the pH meter. It is used for measuring the hydrogen ion activity, i.e., pH of a solution which is often of vital importance in fixing the physical property of the system. The key part of the pH meter is a glass electrode whose potential varies according to the concentration of the hydrogen ions surrounding it but remains unaffected by the presence of other ions in the system. This electrode thus shows specific response towards hydrogen ions in the test solution.

For a long time glass electrode was the only such ionic probe available, but recent researches have produced a number of other electrodes which are useful in measuring other ionic species in solution. A notable advancement in this field came in 1967 with the construction of a calcium-selective electrode by J.W. Ross in the U.S.A. and halide electrodes by Pungor in Hungary. Work has since proceeded quite rapidly and ion-selective electrodes are now available for NH_4^+, Cd^{++}, Ca^{++}, Cu^{++}, Pb^{++}, Ag^+, K^+, Na^+, CN^-, F^-, I^-, and Cl^- ions. These electrodes show sufficient selectivity towards a particular ion and, like the familiar pH electrode, are able to measure the ion concentrations in aqueous solution in the range of 1 to 10^{-6} M. The electrodes also find use in biochemistry where suitable enzyme-selective electrodes can be prepared for individual need. The principle on which ion selective electrodes work can be demonstrated with the familiar electrochemical system for measuring hydrogen ion activity. It consists of a glass electrode and a calomel electrode dipped in a test solution. The potential, i.e., E.M.F. generated is measured by potentiometer.

The glass electrode consists of a silver-silver/chloride electrode enclosed in a thin glass membrane. The total E.M.F. generated by such a system varies proportionally as a result of change in the cationic activity (concentration of H^+ in this case) in the solution. There is little interference from other cations in the system.

The reason for this selectivity is that the glass membrane which is interposed between the solution and Ag/AgCl electrode interacts with the hydrogen ion in solution. The adsorption of hydrogen ion generates an additional potential called membrane potential at glass-solution interface due to establishment of a charged double layer. The magnitude of this membrane potential depends on the extent of ionic adsorption on the glass membrane surface and thus, in turn, on the concentration of the ion in the test solution. The potential on the glass electrode can therefore be thought to arise in two parts; firstly, due to silver-silver chloride electrode inside it, and secondly due to membrane potential.

In the absence of glass membrane the potential measured will be non-specific depending upon the total concentration of ionic species in the solution. The membrane potential, on the other hand, is a specific term and depends on the nature of the membrane. Our prime concern in the theory of ion-selective electrode will therefore be with the nature of membrane and the membrane potential. The important contributions to the membrane potential will arise either due to selective adsorption of ions or, if the membrane is porous, also due to different diffusion rates of ions resulting in a liquid junction potential. In most of cases the membrane potential will be a combination of these two terms. For any ion-selective electrode a suitable selective membrane is available. Some of the representative ion selective electrodes that are commercially available are described below.

Solid ion-exchanger membrane type electrodes

(a) *Glass-membrane electrode.* pH electrode and sodium electrode are the important examples of this type of ion selective electrodes. The electrode consists of a thin-walled glass membrane bulb in which a silver/chloride electrode is sealed. Electrodes of different selectivity can be prepared by varying the composition of glass membrane. Some of the glass compositions that are reported in literature are given in Table 1.

Table 1

Type of electrode	*Composition of electrode*		
Lithium	15%LiO_2	25%Al_2O_3	60%Sio_2
Sodium	11%Na_2O	18%Al_2O_3	71%SiO_2
Silver	11%Na_2O	19.1%Al_2O_3	52.9% SiO_2
Hydronium (pH)	14.3%LiO_2	7%BaO	68.7%SiO_2

(b) *Inorganic insoluble precipitate membrane electrode.* Halide electrodes and some of the divalent cation electrodes like copper, lead and silver selective electrodes are examples of this type. Their construction details are quite simple. The inorganic precipitate, either as a single crystal or pressed in a pellet form (with or without binder), serves as a membrane. For internal contact either the membrane may be connected by a platinum wire or may be connected through an internal reference electrode as in case of glass membrane electrode. Lanthanum fluoride single-crystal electrode is an example of such electrode. This electrode works excellently as a fluoride sensitive electrode. Silver halide preipitate can be immobilised in a silicon rubber matrix and this type of membrane is used to make halide electrodes. For preparation of cation selective electrodes and sulphide electrodes, the respective sulphide is mixed with silver sulphide and pressed into a pellet to be used as a membrane.

Liquid ion-exchanger membrane electrodes

The calcium selective electrode is one of the early examples of this type. It uses liquid ion-exchanger dissolved in a viscous water-immicible organic solvent to form a film that acts as a membrane. Fritted glass or any other polymeric membrane may serve as support. For making the ion-selective electrode the liquid ion-exchanger is used in the respective cationic or anionic form. For internal contact a reference electrode is used. A calcium-selective electrode is constructed by using calcium salt of didecyl phosphoric acid dissolved in dioctyl phenyl phosphate as solvent.

Electroneutral membrane electrodes

The important electrodes in this group are ammonium and potassium-sensing electrodes. For potassium specific electrode, the membrane consists of valinomycin dissolved in a cyclic ether. The valinomycin serves as a complexing agent for potassium. For ammonium sensitive electrode a mixture of monactin and nonactin (cyclic organic compounds) is used as complexing agent. The internal electrode contact is made through a reference electrode, e.g., silver —silver chloride.

Biological electrodes work on the principle that certain reactions produce ammonia, carbon dioxide or oxygen as a result of reaction with enzymes. By proper modification of the respective ion-sensitive electrodes, the concentration of the enzyme and also the concentration of the counter-part compounds can be estimated.

G. Prasad
B.K. Saikia

Chemosterilants for rodents

THE economic loss due to rats is beyond estimate. They are capable of destroying any item on the earth, be it a piece of clothing, furniture, wirings or food grain. In India, according to available estimates, 6–20 per cent of the food grains are lost to rats. The annoyance caused by rats sometime reaches unbearable proportions. Rat bites are of frequent occurrence and there are instances where rats have reportedly gnawed infants to death in some of the villages in India.

Inspite of its magnitude the problem of rat control has received very little attention. With the absence of "natural check" in the form of plague, the population of rats, atleast in some places, has phenomenally increased, particularly in townships indulged in grain trade. Their control has remained an insurmountable task and decades of research on rodent control has proved of very little help. The methods of rat control are as conventional as they were twenty years ago. However, of late, some progress appears to have been achieved.

Several methods of rat control are employed, use of chemicals—known as rodenticides—being the most favoured one. These rodenticides are classified under two groups, viz., single-dose rodenticides and multiple-dose rodenticides. Among the rodenticides used, zinc phosphide occupies the prime place in India. The advent of anticoagulants—the multiple-dose rodenticides — has revolutionised the approach to rodent control and great success has been achieved in controlling rats in many places. However, with reports of resistance to anticoagulant compounds among rats appearing from many countries, the rodent control problem has received a set back and the search for newer rodenticides and newer methods of rodent control is under way.

The development of rat and mouse strains resistant to Warfarin and other anticoagulants pressed the need for other means of rat control. The most important drawback of both anticoagulant and other rodenticides is that they fail to achieve complete eradication. This results in an accelerated breeding by the surviving animals and the population is restored to its original size. Some of the big cities in India, like Bombay, are a glaring example where inspite of control measures undertaken the population of rats continues to remain more or less static.

The success achieved in controlling many insect pests by chemosterilisation suggested the possibility of exploring similar methods for rodent control. For that chemosterilants for rodent control have been advocated. A chemosterilant is a chemical that can cause permanent or temporary sterility in either sex or both sexes, or through some other physiological mechanism reduce the number of offsprings or alter their fertility. There are various ways in which chemical agents can interfere with physiological process of reproduction. Interference with reproduction may take the form of direct or indirect damage to the developing or mature gametes before copulation, or after copulation before fertilisation takes place. The union of sperm or ovum may be prevented, or the fertilised ovum may be hindered during the process of implantation into the uterus. The implanted embryo may be subjected to chemical attack in various ways during different stages of its development. Neonatal interference with sexual development in the offspring causing irreversible sterility, or other chemically induced factors that cause mortality by reduced lactation or abnormalities in the young, would suppress populations. Those compounds which induce mutations can also serve as chemosterilants if they decrease fertility or increase early mortality in subsequent generation. Development of chemosterilant for vertebrate pest control has derived immense benefits from the oral contraceptives for human beings. The chemosterilants developed so far for rats are still in experimental stage and have not been employed for rat control.

In order to be an ideal chemosterilant it should possess some degree of specificity and should be effective orally in a single dose. It should also affect both sexes or atleast females. Those affecting males are less desirable. The sterility should be irreversible and of a permanent nature.

Among sterilants several non-steroid compounds such as clomifene and transclomifene have been evaluated. Steroid hormones, estrogen and androogen, can serve as reproduction inhibitors. Several potent synthetic steroids like mestranol, quinestrol and diethylstillbestrol also possess chemosterilant properties. The administration of mestranol through mother's milk to the litters within few days after birth is likely to induce sterility in both the sexes. However, any such use lacks practicability as it is difficult to trace pregnant mothers about to deliver and feed them with mestranol.

There are a number of steroidal and non-steroidal compounds that can be used as abortifacients. There are also a number of steroidal and non-steroidal compounds that can inhibit implantation and inhibit events after copulation in other ways. These compounds should generally be available to rodents immediately after conception or during early gestation.

Among the chemosterilants for males, the use of hormones for inducing sterility in males lacks practicability. Several alkylating agents, however, offer great possibilities for sterilising male rats. Nitrogen mustard may be a good sterilant. Ethylenimine and methane-sulphonate alkylating agents (tretamine, thiotepa and busulfan) have been shown to be antispermatogenic compounds. Nitrofurans, e.g., nitrofurazone, nitrofurantoin and related compounds have also been reported to interfere with spermatogenesis. Colchicine, a rather toxic alkaloid found in a number members of the *Liliacae* family, has been shown to possess chemosterilant activity. 3-chloro-1, 2-propanediol has also shown promise as a sterilant for male rats.

The success of chemosterilants in the future rodent control will depend upon the number of dosage required, specificity of the chemosterilant against any particular species, and reversibility or irreversibility of its effect. Compounds requiring multiple feeding will not prove of great help.

The chemosterilants will prove valuable in keeping rodent population in check in association with control measures like trapping and/or baiting campaigns. The progress in development of chemosterilants will lead shortly to the development of an assortment of chemosterilants for use, just as we have a variety of rodenticides today. The choice of a chemosterilant will depend on the characteristics or biological activity most suitable for a particular situation taking into account safety, effectiveness, duration of action, and so forth. The use of chemosterilants in rodent control would mean less hazards to man and his domestic animals as these compounds are relatively non-toxic compared to rodenticides.

In the field, rodent populations will be exposed to chemosterilants in the same manner as the lethal rodenticides; baits being the primary method. Water baits and wet or dry baits of cereal, fruit, meat, etc., will have to be used. Compounds requiring repeated feedings like anticoagulant rodenticides will have to be kept ready at bait stations.

D.M. RENAPURKAR

Bounties of delta

THE term 'delta' originated from the shape of the Greek letter '△'. In the recorded history, the word DELTA was used by Herodotus in 400 B.C. for the triangular sedimentary plain at the mouth of Nile. It is the track of coastal land bounded by the most divergent branches of a river's mouth and traversed by other tributaries of the river. This triangular area is formed by the fine silt, also called alluvium, brought down in suspension by a muddy river and is deposited when the river's current weakens on reaching the sea. The coastal plain is the alluvium formed during the course of geological history. This is the area thickly populated anywhere in the world due to its high fertility for agriculture, fisheries and mineral resources. The petroleum reserves are found in these ancient sedimentary deposits of deltaic origin.

The shape of the delta is often compared to a 'bird's foot' as in case of the Mississippi, or 'arcuate' as in case of the Nile, Rhine and Niger. Generally low energy waves, small tides and minor long-shore currents favour the formation of a delta. The progradation of the delta depends also on the silt load of the river. Diversions in the course of a river due to heavy discharge also result in progressive enlargement of the delta. The Mahanadi delta, the Godavari delta, the Krishna delta and the Cauvery delta are the major deltaic environments exhibiting these features.

When the wave action is strong with a high tidal amplitude, the progradation of the delta is very slow or absent as in case of the Ganges-Brahmaputra system.

Delta cycle

In a stable area the progradation continues and the gradient of the distributaries becomes progressively lower, reducing the stream's efficiency to transport the silt load. If the river cannot divert its course, the delta plain elevates at a rate corresponding to its rate of progradation without building up any delta laterally. This is the condition in the Mekong river (South Vietnam) and the Burdekin river (Australia). The landward boundary of the Godavari river was 80.50 km interior from the coastline about 2000 years ago. The present day delta has been formed during the course of this long period.

In a subsiding delta, the initial deposits subside over a long period and the subsequent deposits overlap them and prograde seaward. The Mississippi delta, the Niger delta, the Ganga-Brahmaputra delta, etc., are some of the well known examples of this kind.

The term also applies to lake delta and tributary delta of a river. Lake delta is formed at the side of a lake where the tributary enters and extends occasionally outwards as far as the opposite shore and results in the lake being divided into two separate water bodies as in Thun and Brienz lakes in Switzerland. This type of delta formation is mainly due to enormous silt load brought into the lake. The tributary river delta is usually a small one, occurring at the junction where a fast flowing muddy tributary enters a slow flowing main river.

M. SUBRAHMANYAM

Seedless fruits

IN the last few decades seedless fruits have drawn the attention of horticulturists the world over, mainly due to their high commercial value. The seedlessness is often linked with parthenocarpy (i.e., production of fruit without fertilization of the ovule) but, whereas the latter does not include the possibility of fruit production by fertilization, seedlessness may be produced by subsequent collapse of the seeds produced even after fertilization. A seedless fruit may develop parthenocarpically but a parthenocarpic fruit may not necessarily be seedless.

Normally fertilization results in the formation of fruits and so it is inferred that the process of fertilization is essential for the formation of fruits. However, in certain varieties of grapes, oranges, cucumbers, figs, bananas, pineapples, papayas, mulberries and tomato, the fruits are produced even without fertilization and are devoid of viable seeds.

Countless attempts have been made in the past to produce seedless fruits, but only a few have achieved success. In 1930, a Japanese, S. Yasuda, in an experiment pollinated the flowers of brinjal as usual, but before the pollen tube could enter the region of the ovary, the style was cut off from the base to prevent fertilization. The growth of the ovary still continued and the resulting fruits were seedless. Thus it may be inferred that the pollen grains can stimulate the growth of the fruits even without actual fertilization of the ovules.

Various experiments were performed, using pollens from different plants to induce seedlessness, with varying degrees of success. In 1849, a German, K.F. Gaertner, for the first time demonstrated the production of seedless fruits in some cucurbits using the spores of *Lycopodium*. Seedless fruits in tobacco, sweet pepper and tomato were produced with the pollens of different species of plants and also by certain chemicals. Later researches revealed that even the extract of pollen grain is sufficient to induce the formation of seedless fruits. A detailed study of these chemical substances revealed that they were members of a class of compounds called auxins.

Pollen tubes also secrete certain chemical substances which, after diffusing into the ovary, induce the formation of fruits. Seedlessness is prominent in cases where these chemical substances are allowed to diffuse into the ovary but fertilization is prevented. Thus it is evident that the stimulation given to the ovary is chemical in nature. The pollens of many of the plant species are rich in auxins which may be responsible for inducing fruit formation. In some species like pineapple, banana and grapes, the pollination and fertilization are entirely absent and the fruits produced from unfertilized flowers are seedless.

The question why some plants naturally produce seedless fruits remained unanswered for a long time until an American, F.G. Gustafson, in 1939 studied the auxin content in the ovaries and flower buds of different species like orange, lemon and grape varieties and arrived at the conclusion that the auxin content is higher in the ovaries of naturally seedless varieties than in the ovaries of those which produce seeds. He also found that the auxin content in grape seedlings of seedless variety is higher than that of seeded ones. So the reason as to why some plants produce seedless parthenocarpic fruits is that their ovaries contain sufficient auxin to promote growth of the fruit even without fertilization, whereas in plants which do not produce parthenocarpic fruits the auxin content is not enough to cause stimulation of growth of the fruit.

In earlier times the phenomenon of seedlessness was regarded to be unrelated to hybridity and polyploidy, but now it is believed that seedless varieties have arisen through gene mutations. The mechanism by which seedlessness is induced by the genetic constitution of the plant is perhaps through a disturbance in the auxin content of the fruit tissue. Unusual weather conditions like heavy fog and low temperatures also sometimes lead to the production of seedless fruits, possibly through alterations in the auxin metabolism. However, auxins alone do not seem to be the factor for this inducement; it may be associated with temperature effect.

Hormones play an important role

in the development of fruits. The ovary requires hormonal stimulus at various stages of development. At anthesis (opening of the flower bud) it has a low auxin content and this deficiency is made up by pollination which saturates the deficiency. But pollen does not provide sufficient amount of auxins to be stored in the ovary wall and to initiate the development of fruits. The bound auxins present in the pistil of many species are converted into active auxins under the influence of an enzyme coming from the pollen tube and as a result auxin content of the ovary is made up to the required level. The production of seedless fruits by application of growth hormones to unpollinated ovaries has been attempted in the past by many workers and this knowledge has been employed in horticulture in production of seedless fruits.

Various substances like indole acetic acid, indole butyric acid, indole propionic acid, alpha naphthalene acetic acid, phenyl acetic acid, methyl indole butyrate, alpha naphthylthioacetamide, 2-4-dichlorophenoxy acetic acid, 4-chlorophenoxy acetic acid, potassium naphthalene acetate and gibberellic acid have been employed. The fruits developed are comparable in size to those obtained after natural fertilization. Recently gibberellins have been successfully employed for purposes of fruit setting in tomatoes.

Auxins are generally applied after the flower has bloomed while the gibbrellins are used at anthesis. These substances may be applied to any part of the plant including style, ovary, pedicel, shoot or root. The concentrations of the growth hormones used in lanolin paste range from 0.05 to 2.0%, and 0.0001 to 0.2% when used in aqueous solutions.

K.C. SRIVASTAVA

Trace metals in human hair

WE have an increasing concern about heavy metal pollution particularly caused by lead, mercury and cadmium. The major cause of heavy metal toxicity is its reaction with body sulphur. When the heavy metals enter a living organism they relentlessly seek out sulphur in that organism. Enzymes, the crucial catalyst-regulators of life chemistry, are dotted with sulphur atoms and thus become the natural target of heavy metals. The subsequent chemical bonding between enzyme sulphur and the heavy metal destroys enzyme function causing heavy metal poisoning.

The hair which is protein in nature has plenty of sulphur and heavy metals are readily trapped in them. Hair assume the function of a minor organ for elimination of trace elements in addition to the major excretory organs of the body. The relatively high concentration of trace metals in hair and the convenience in hair sampling has made it possible to use hair analyses for early diagnosis of heavy metal toxicity. The trace metals are slowly accumulated in the body due to slow excretion. Therefore, a low exposure over a long time to these metals builds toxic levels. One of the worst manifestations of this phenomenon is lead poisoning in children. This happens over a long period of time and usually goes unnoticed until irreversible damage has been done. One of the main sources of lead in children is the eating of small pieces of lead containing paints. The toxic level of lead in the body leads to life long mental retardation or death. Children with lead poisoning have been found to have high lead content in hair samples, The hair analysis for metal contents, specially lead, can be used for early detection of slow poisoning in children. The classical clues obtained about Napoleon's death are very interesting. Following the analysis of Napoleon's hair it was claimed that he had been poisoned with arsenic because of high concentration of arsenic in his hair.

The metals of recent concern, i.e., lead, mercury, cadmium, nickel, manganese, zinc and copper which are the products of industrial pollution and auto exhaust emissions are normally present in the atmosphere near urban areas. These metals enter the body through inhalation of contaminated dust and through ingestion of food and water contaminated by the fall out. In a survey of the industrial city of Port Arthur, Texas, U.S.A. which has a gasoline production centre, the concentration of lead, mercury, cadmium, zinc, nickel, copper and manganese in the hair has been correlated with hair colour and age. The higher concentration of lead, mercury, cadmium and copper has been found in the older section of the hair reflecting the storage of these metals in the body tissues. The concentration of lead content in hair has been found to increase with age. The relation of copper and zinc concentration with hair pigmentation or colour is fascinating. A significantly higher zinc and copper content in hair is attributed to their function in the production of the melanin pigments which have been reported to be metal complexes derived from the amino acids, the tyrosine and tryptophane. The increasing knowledge about the metal content in hair makes hair analyses a potential diagnostic tool in metal toxicology.

ZAKA IMAM

Bioluminescence in fishes

CERTAIN species of oceanic fishes are bioluminescent. They have, especially on their ventral surfaces, dermal light organs or photophores emitting light rays which act as a sort of camouflage to make them invisible to enemies.

The highly directional property of light in sea water enables the shiny, reflecting dorsal and lateral sides of fishes to match the background. This helps the fishes to move about unseen, when viewed from above and from the side. Such is not the case when the fishes are watched from below, because their ventral surfaces are clearly exposed as dark, moving shadows against the bright surroundings making them easy targets.

In their struggle for survival, some fishes produce bioluminescence that corresponds exactly to the environmental light passing downwards on either of their sides. The emitted light—matching in colour and intensity to the environmental light—obscures the ventral outlines of fishes. Thus, by means of self-illumination, which is similar to background light, fishes develop a system of camouflage to move about inconspicuously.

Recent investigations on common lantern fishes *Tearletonbeania crenularis*, usually found in the North Pacific Ocean, revealed the general underlying mechanism by which fishes emit light rays.

In common lantern fishes, the light organs are found in rows along the ventral surface of the head and body with clusters of isolated photophores near the eyes. Each photophore consists of a mass of innervated photogenic tissue, a pigmented mantle and reflector. Some of them are enveloped by a superficial lens, scale and reflector system which gathers light from the photogenic tissue and modifies the colour and intensity of emitted light. Further, the large, bulging eyes of common lantern fishes are well suited for vision even in dim light. A crescent-shaped gap, or aphakic aperture, is present between the central margin of iris and the ventral border of lens. The aphakic aperture helps the retina to collect light rays from the environment as well as from the light organs above the eyes (supraorbital photophores).

For the fishes to be able to match their ventral illumination with that of background light, the emitted light must have essentially the same properties as the surrounding light. Now, commonsense tells us that if the fishes were to have maximum invisibility when viewed from below, they should be able to collect, compare and adjust the intensity of emitted light to that of environmental light. How are they able to perform such a complicated task?

Experimental findings indicate that the lantern fishes could detect a diffuse spot of light produced by supraorbital photophores whenever the intensity of light in the photophores is greater than that of background light. By adjusting the output in the supraorbital light organs until the spot of light disappears, the fishes, it is supposed, are capable of generating an intensity of light equal to the intensity of surrounding light.

Once the intensity level is known, the data can be used in controlling the ventral illumination. Thus, by an ingenious technique, the bioluminescent fishes measure the level of intensity required for their ventral illumination, which camouflages them from enemies. By using the same method, the fishes can modify their bioluminescence whenever a change in the background light occurs, and move about safely without fear of attack from below.

S.K. TATINENI

Oils, fats and waxes

ABOUT 100 years ago the French chemist, Chevreul, demonstrated that oils and fats such as olive oil and lard were glycerides of fatty acids. On this basis the handling and refining of edible oils and fats was remodeled. Some twenty years ago two French scientists, Sabatier and Senderens, made another important contribution to this field when they transformed oleic acid and oil into solid stearic acid. Based on this reaction, technologists have devised several ways for the "hardening" of edible oils into edible fats which is now a well established branch of this industry.

The oils, fats and waxes of both animal and vegetable origin are esters of organic acids belonging to the fatty acid series. It is because of their presence in fats that these acids have been named fatty acids. An ester is formed by the combination of an alcohol and an acid, with the elimination of water. The oils and fats are esters of a wide variety of fatty acids with glycerol which is an alcohol. The waxes are also esters of the same kind of acids, but here the alcohol is different. The fatty acids belong chiefly to three types: (i) saturated series (stearic acid), (ii) oleic series (which are unsaturated lacking two hydrogen atoms), and (iii) the highly unsaturated series (lacking four or more hydrogen atoms).

The glycerides of the saturated series melt at a higher temperature than those of the oleic series. A fat is rich in glycero-stearate with some glycero-oleate admixed. On the other hand, an oil is rich in glycero-oleate and poor in glycero-stearate. Among the glycerides of the saturated acids, a further consideration must be made. If the three acid residues are the same, the fat is rather hard; thus glycero-tristearate (called stearin for short) melts at 72°C. If the three acid residues are unlike, the fat has a lower melting point; thus glycero-distearate-monopalmitate melts at 63°C.

In each oil and fat a number of different fatty acids occur, sometimes as many as ten, six or more being the rule. This makes the study of the composition of an oil difficult enough. The complications of mixed esters such as glycero-distearate-monopalmitate increases the difficulty still more; it is therefore not surprising that there are many oils and fats whose composition is still unsettled.

The study of the composition of oils and fats is based on a knowledge of the constituent fatty acids which occur in a large number of oils and fats.

The most important vegetable oils are cottonseed, linseed, olive, corn, peanut, rape and mustard, coconut, palm and castor, while whale oil and fish oil are the chief animal products. Non-edible oils are mostly used for soap making. Fish-liver oils are used for pharmaceutical purposes, while sperm-oil obtained from the sperm whale is a liquid wax used for lubrication. The best known waxes are carnauba wax and beeswax.

SUBRATA CHATTOPADHYAY

What is shock?

SHOCK is a common term frequently used by layman. During the past several decades shock has been the subject of investigations in the clinics and the laboratories. The published material on shock is voluminous, nevertheless, agreement on what constitutes shock is still lacking.

It was H.F. Le Dran (England) who in 1743 coined the word 'choc' for the first time which may be considered the probable origin of the term. The actual word 'shock' was used in the field of medicine by British scientist C.J. Guthrie in 1815 and subsequently by S. Cooper in 1838.

Shock may range from catastrophic external forces to influences which are obscure and act insidiously. Shock-producing agents need not necessarily be violent or obvious. A healthy young man was struck in the abdomen by the pole of a carriage drawn by runaway horses. There were no apparent injuries to the internal organs, yet he developed shock. Tapping the abdomen of a frog sharply with a blunt instrument leads to shock. Shock can be produced in rabbits by tilting them suddenly from a horizontal to a vertical position.

What then is shock? Clinically, the term is applied to a fairly characteristic and yet somewhat varied syndrome following hemorrhage, injuries (trauma), wounds, burns, surgical operations, anesthesia, bodily disorders involving toxic states, severe dehydrations and disturbances in sodium and potassium levels in the body. Shock is induced by one of the several factors such as profuse loss of blood, injury to tissues and less frequently, excessive or prolonged anesthesia. It is generally believed that a true state of shock is a condition which usually but not always develops after a hemorrhage, injury or operation and which pursues a progressive downward course likely to prove fatal if not treated. Occasionally, shock may occur several days after an apparent recovery and death may follow. Thus, shock may be either acute and precipitant or induced and delayed.

The manifestations of shock are varied. Shock affects mental, nervous and muscular states, respiration, function of the heart and blood circulation. The person under shock is apathetic, restless, has weak voice and exhibits delayed response. His face is drawn and anxious, his eyes lustreless with sunken eyeballs which have a slight upward rotation. He has tremors, twitchings, involuntary muscular movements, muscular weakness and difficulty in swallowing. His skin is pale, ashen grey and slightly cyanotic. His tongue is dry, pale and shrivelled. Respiration is irregular with increased rate of variable depth and occasional deep sighs. Superficial veins are collapsed and invisible and fail to be filled on compression or massage. The heart rate is usually rapid. Cardiac acceleration is a definite part of clinical shock syndrome. The radial pulse is rapid and feeble. Blood pressure is decreased and there is circulatory failure. The patient is conscious and seldom complains of pain but there is universal complaint of intense thirst.

Blood volume and shock

The commonest forms of shock are associated with appreciable reduction—about 30-40%—in blood volume and heart output. In man, reduction of blood volume occurs largely at the time of injury. The subsequent failure of circulation is due to the default of the cardiovascular apparatus. Decrease in blood volume (hypovolemic) is encountered in shock following hemorrhage, wounds, trauma, freezing, prolonged vertical suspension, operations, intestinal obstruction, strangulated hernia, perforated ulcers as also in dehydrations and disturbances in sodium and potassium levels of the body due to protracted vomitting, diarrhoea, drainage, cholera and severe diabetes. In shock due to burns, the intense inflammatory edema causes a great loss of plasma, reduction in blood volume and cardiac output. However, in shock caused by biological agents or other causes following, say, typhoid, paratyphoid influenza, dyphtheria, and venom poisoning, there may not be any reduction in blood volume.

In shocks consequent to loss of large volume of fluid by seepage (as in burns), drainage, excretion, vomiting or exudation into tissues as in crush injuries, there is haemoconcentration of blood. There is hemodilution of blood in shocks due to skeletal muscle trauma, hemorrhage or wounds. Treatment of shock has to take into account whether there is hemo-concentration or hemo-dilution.

Shock—mild, moderate and severe

The heart rate, blood pressure and pulse help in assessing the intensity of shock. In mild shock, the blood pressure is only slightly reduced and the heart rate increased approximately 20% above normal. Moderate shock is characterized by decrease of blood pressure and an increase of heart rate by about 20-40%. In severe shock, the blood pressure is reduced between 40% to nonrecordable values while the heart rate is increased to 40% or more. Pulse becomes extremely feeble and imperceptible in severe shock. There is very severe thirst in intense shock (Table 1).

Table 1. Physiological changes in severe shock

Physiological function	*Variation*
Blood pressure	Decreased
Heart rate	Increased
Pulse	Feeble and fast
Blood volume	Reduced in many types
Thirst	Very high

In some instances symptoms may be present without the development of true shock, or conversely, many symptoms may be absent when true shock is impending. So in arriving at a diagnosis, it is important to relate the existing clinical signs and symptoms to antecedent events and gauge the probability of prospective shock.

While shock due to hemorrhage, wound and trauma is designated as surgical shock, medical shock is the one encountered in severe dehydration due to prolonged vomiting, diarrhoea, deficient intake of fluids, sodium depletion in the body with high concentration of potassium in blood, as also shock consequent to diabetes mellitus, neoplastic diseases and acute infections.

The term shock has also been applied to other unrelated conditions such as nervous shock, electric shock, insulin shock, and shell shock (nervous and mental conditions following concussions caused by powerful explosions more or less permanently disabling the patient).

Physiological changes

Though in the early state of shock, blood sugar (glucose) increases as a result of the breakdown of glycogen of the liver to glucose, in progressive states there is a fall of blood sugar due to intensive utilization of sugar by tissues. Blood lactic and pyruvic acid levels increase. Energy donors, namely, adenosine triphosphate and creatine phosphate are steadily depleted especially in liver and kidneys with a less marked loss in muscles. Substantial reserve of the above two substances remains in heart and brain even in the terminal stage. Liver functions are weakened as the severity of shock increases. There is loss of water and sodium from the body resulting in deficiency of sodium in the blood. Loss of water causes reduction in the plasma volume. Depletion of sodium from the body causes an increase of potassium in blood which has the dangerous biochemical effect of stopping the heart beat (Table 2). Salt and sugar depletion in severe shock has to be corrected to save the person.

Table 2. Biochemical changes in severe shock

Biochemical constituents	*Variation*
Glucose in blood	Decreased
Lactic acid in serum	Increased
Pyruvic acid in serum	Increased
Amino acids in serum	Increased
Sodium in serum	Decreased
Potassium in serum	Increased
Bicarbonate in plasma (alkali reserve)	Decreased
pH of blood	Lowered
Water in the body	Decreased in many cases
Energy-rich compounds (ATP and creatine phosphate)	Depleted in liver, kidneys and muscle

Treatment

Transfusion of blood or plasma and restoration of blood volume are important measures in the treatment of shock. Where there is hemoconcentration plasma has to be used. In an average person, in severe shock, about two litres of blood may be given either intravenously or intra-arterially. Intrarterial route immediately improves blood circulation in the brain and heart.

Even the administration of salt (sodium chloride) alone in isotonic solution restores blood volume and exerts a favourable influence in getting over the shock. While B-complex vitamins are reported to have no useful effect, vitamin C premedication appears to have some protective action as established in guinea pigs. However, administration of vitamin C during shock has not been found to exert any favourable effect.

S. RAMAKRISHNAN

Defensive chemical secretions in insects

A LARGE part of the insect world preys upon other insects. Many insectivorous birds, lizards and frogs also prey upon insects. The insects possess a variety of devices for their defense against these predating enemies and the chemical secretions are one of them. Insects also use their chemical secretions against the systemic action of microorganisms.

The defensive chemicals are secreted by some special entegumentary glands either as liquids or vapours. They have nauseous smell and repellent properties. The chemicals associated with mandible and sting apparatus of many insects are used both as offense and defense weapons.

The defensive glands

These glands are multicellular and consist of a large glandular epithelium and a sac-like cuticular reservoir of varying size in which the secretions are stored. The location of glands as well as the number per individual vary greatly. They may be on head, thorax or abdomen where they occur singly or in groups. For example, in cockroaches there are one or two, in Tenibrionoids two or four, etc. In Heteroptera the repugnatorial or odoriferous glands open to the exterior by means of a pair of ventral pores or slits situated near the coxae of the hind legs.

The pygidial glands in Coleoptera are defensive in function and secrete corrosive pungent fluids. They are paired organs and open in close association with the anus. In *Feronia melanaria* (vulgaris), each gland consists of spherical acini composed of gland cells; each acinus (Fig. 1) opens by a separate duct into the common canal of that side. The secretion of each cell is discharged by a minute simple intracellular ducteole which communicates with the lumen of the gland.

The setal glands have been observed in some of the Lepidoptera larvae including Megalopygidae, Eucleidae, Saturnidae, Arctiide and Lymantridae. The seta becomes toxic by the development of a poisonous gland cell (Fig. 2) immediately adjacent to the trichogen which extends to the lumen of the seta. When the tip of seta is broken the secretion is ejected. The latter causes urticaria in man.

The glands produce substances of very high toxicity which are toxic even to the animals that produce them. It is surprising that how the products in the gland are isolated physiologically from the rest of the system. The cuticle in the reservoir might be impervious to an outward diffusion of the stored content. Also, the intracellular canaculi might be allowing the discharge out of cells but not backflow. There is a possibility that in some glands the toxic principles are actually synthesized in the reservoirs from a series of relatively harmless precursors manufactured in separate cells.

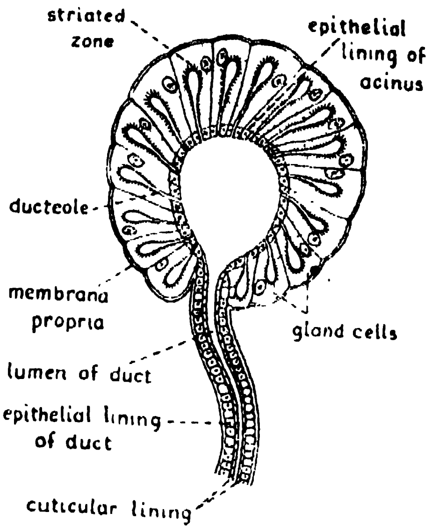

Fig. 1. Semi-diagrammatic section of an acinus of the pygidial gland of a carabid beetle

Mechanism of discharge

In some insects the fluid is expelled simply by muscular compression of the reservoir, as in the walking stick *Anisomorpha buprestoides*. The grasshopper *Poekilocerus bufonis* curves both ends of its body downwards, producing pressure on a gland in the first abdominal tergite, while at the same time it opens the gland orifice and allows the secretions to be ejected. In the cockroach, *Eurycotis floridana* the fluid discharge is controlled by the longitudinal muscles

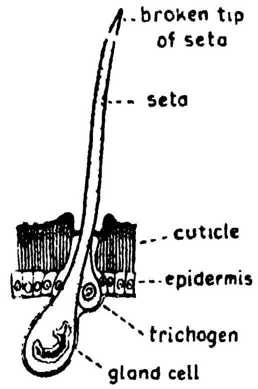

Fig. 2. Setal gland of a caterpillar showing a large gland cell and broken tip of seta

which attach the gland to the sixth sternite; contraction of these muscles would elongate the sac, decrease its volume and force out the fluid through the narrow slit of the closely opposed sternites.

In some of the lubber-grasshopers of the genus *Rommalea*, droplets of dark brown fluid together with air are released from the mesothoracic spiracles, with the consequent formation of a conspicous froth on the sides of the thorax. The process is accompanied by a hissing sound and, some times particularly when the animal is attacked by birds—by a threat display, in which the bright red hind wings are exposed.

In some of the bombordier beetles of the genus *Brachinus*, the free oxygen is liberated as a result of an explosive chemical reaction inside the reservoir which provides the pressure for the expulsion and dispersion of the chemical.

The chrysomelid, *Melasoma lapponica*, has eighteen glands which open through conical tubercles arranged in two rows along the dorsolateral portion of the meso and metal thorax and seven abdominal segments.The defensive fluid is stored in reservoirs which are held in place by two muscles. The gland is everted by blood pressure and the muscles holding the reservoir relax so that a small droplet forms at the tip of the tubercle. When disturbed, the larva ejects a small droplet from each of the eighteen tubercles. The droplets often remain on the tubercles less than a second and are withdrawn mostly simultaneously. The larva is able to discharge its odour secretion five to six times in succession.

Nature of the defensive secretions

The defensive secretions produced by most species are usually a mixture of two or more compounds. In the cockroach species *Eurycotis floridana* and *Cuticula sorror* only the 2-hexenal have been detected. Bazinet found eleven compounds in the secretion of the fossorial Hemipteran, *Scaptocoris divergens*; these were identified as propenal, propanol, butenal, pentenal, 2-hexenal, heptenal, octenal, furan, methyl furan, methyl quinone, and an unidentified quinone. In *Nezara virudula* four compounds have been found. They are trans-2-hexenal, 2-decenal, Tridecane and an undetermined compound. Stored grain pest, *Tribolium castaneum* secretes 2-ethyl-1-4 benzoquinone, 2 methyl-1-4-benzoquinone (Toluquinones) and 2-methoxy-14-benzoquinone. Among Coleoptera only cantharidin have been found in species of *Lytta*, *Meloe*, *Zonabris*, etc. In *Carabus* and *Cychrus* (Coleoptera) the ejected fluid contains butyric acid.

In some insects, the chemical secretion is expelled forcibly as a spray. The range of spray is not more than a few inches as in *Brachinus bellistorius*, *Diploptera punctata* and *Forficula auricularia*, but sometimes is 30-40 cm as in *Blaps nitens*.

The insects do not discharge the chemical at random but actually aim it at the source of disturbance. The cockroaches, *Eurycotis floridana* and *Neostylopyga rhombifolio*, by turning the abdomen to the right or left can control the direction of discharge from their single midventral abdominal gland. In the case of earwig, when it is stimulated, it revolves its abdomen bringing its pincers to bear on the disturbing object, thus automatically pointing the gland toward the stimulus.

The red ant can discharge formic acid from the tail end of its body to a distance of 15-30 cm. When alarmed or enraged, the workers stand on the tip of their feet with the gaster bent between their legs so as to eject the venom against any predator.

Social insects "pool" their defensive resources through coordinated group behaviour. Ernst has made detailed observations on a laboratory colony of an African species of *Nasutitermes*. In this termite, aggregations outside the nest often consisted of as many as 70 to 90% of Nasuti soldiers.

The workers of *Tetramorium simillum* ant protect their food by pointing their abdomens away from the food and discharging fluid at ants of other species. The workers of *Tetramorium* themselves are never hit by the obnoxious fluid. By what sensory criteria this ant distinguishes between intruders from its own kind is not known.

Some of the secretions have been shown to have antimicrobial action. Gonyleptidine, a mixture of p-benzoquinone derivatives, is a volatile antibiotic effective against several strains of pathogenic bacteria. The simpler quinones of *Tribolium* have bactericidal properties.

A fossorial Hemipteran (*Scaptocoris divergens*) adults have been found to secrete a complex mixture of about 11 compounds (7 aldehydes, 2 quinones, and 2 furans). This complex mixture can kill the fungus *Fusarium oxysporum*. This fungi cause fusarium wilt of banana. Hence, the secretion is responsible for the control of *Fusarium*.

J.P. SRIVASTAVA

Magnetic bubble memory devices

MAGNETIC bubble memory devices were first reported about three years ago at the Bell Telephone Laboratories. The magnetic bubbles are found in a certain class of uniaxial materials, called orthoferrites, which are rare-earth iron oxides. The bubbles are cylindrical domains and constitute an ensemble of magnetic spins stable under the combined influences of magnetostatic energy, domain wall energy and the applied field. There is a critical diameter above which it becomes highly unstable and breaks up to form a strip domain. In Sm Tb orthoferrite the bubble diameter is 0.0038 mm and the storage capacity is 25000 bits per 6.45 sq. cm.

By positioning a conducting loop above the bubble, its motion can be controlled. If the force on the domain is attractive, the bubble will retain its size under the current loop. Thus a one dimension shift register is easily realised by having a number of such conducting loops in succession. An array of loops in the other perpendicular direction gives us a motion in two dimensions. A bubble covers a distance equal to its diameter in 100 nano seconds and experiments with yttrium orthoferrite have shown that in this material the bubbles move with the highest velocity. The presence of a bubble can be detected nondestructively in a number of ways. In one such device, a conductor pick-up loop senses the voltage induced in it as the bubble moves across it. Optical methods involve a change in the intensity of transmitted light. In a digital system formation of a bubble indicates binary "1" and when not formed indicates "0".

The first operating bubble memory device has been recently built in Rockwell Electronic Laboratories in U.S.A. It is a 64 bit shift register with data control equipment and magnetostrictive type of detection. This device is believed to have a 100 fold improvement over a similar disk memory unit. This breakthrough in bubble memory devices paves the way for bigger units with capacities of the order of 10^9 bits.

K. RAMANI

NEWS AND NOTES

(Continued from Page 555)

coming its associate (1929-40), associate member (1940-48), member (1948-54) and professor of cell biology (1954-71). He also held the position of Librarian of Rockefeller University (1965-71) till he retired in 1971.

The genetic material that Dr. Mirsky isolated for the first time in 1940's from the liver and the thymus of calves was called chromatin, a mixture of DNA, protein called histones and other proteins. He also devised biochemical methods to isolate and purify nuclei, DNA and histones. His work on genetic materials in the 1940's paralleled the discovery by other Rockefeller University scientists led by Dr. Oswald T. Avery that the genetic elements in cells were contained in DNA. Later Dr. Mirsky found that the ratio of DNA and histones in cells did not change during cell division and that histones played some role in controlling the way the gene operated. He also carried out research on nucleoproteins, hemoglobins, nuclei, chromosomes and cell biochemistry. He was a member of the U.S. National Academy of Sciences.

BHAKTI DATTA

IT PAYS TO
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NEWS & NOTES

Dr. Eschenmoser receives Welch Foundation Award

DR. Albert Eschenmoser, Head of the Organic Chemistry Division of the Swiss Federal Institute of Technology in Zurich, has recently been named winner of the $75,000 annual chemistry award of the Robert A. Welch Foundation of Houston. The citation mentioned Dr. Eschenmoser's "creative contributions to the synthetic chemistry".

Born on August 5, 1925 young Eschenmoser was educated in the Swiss Federal Institute of Technology from which he received a Ph.D. degree in organic chemistry. He started his career as an instructor of organic chemistry in 1960, in the same Institute becoming its additional Professor in 1965 and full Professor in 1969. As a visiting Professor he carried out research in Massachusetts Institute of Technology (1965) and University of Wisconsin (1970). Recipient of numerous awards including Kern Award (1949), Werner Award (1956), Ruzicka Award (1958) and Fritsche Award (1966), Dr. Eschenmoser published more than one hundred papers in major chemistry journals reporting his original findings in synthetic organic chemistry.

R.K. DATTA

Technologist Dr. Bush passes away

DR. Vannevar Bush, former President Emeritus of Massachusetts Institute of Technology Corporation, who marshalled American technology for World War II and ushered in the atomic age, died on June 28, 1974 at Belmont, Mass. at the age of 84. Computer pioneer and Dean of Engineering at Massachusetts Institute of Technology in the 1930's, Dr. Bush developed an early analogue computer—a 100-ton electronic brain that was kept under wraps and secretly used to solve America's wartime military problems. During the War he headed the Office of Scientific Research and Development and mobilized about 30,000 scientists and engineers to work on everything from portable latrines to the atom bomb. He had overall responsibility for developing such sophisticated new weapons as radar, the proximity fuze, fire control mechanisms, amphibious vehicles and ultimately the atomic bomb—devices that overnight revolutionized the concept of war. A master craftsman at steering obstacles whether they were technical or political, Dr. Bush was a man who got things done. It was his skill along with shrewdness and driving energy that made a decisive contribution to the Allied victory in the War and, further, established a system of national support for basic research that has since made American science the most vigorous and productive in the world.

Born on March 11, 1890 young Bush was educated in Tufts College, Boston from where he received M.Sc. degree in electrical engineering in 1913. He earned his Ph.D. degree in Harvard University and Massachusetts Institute of Technology (1916), which had a joint programme at that time. In 1919 he became an Associate Professor of Power Transmission at Massachusetts Institute of Technology. There he was Professor (1923-32) and Dean of Engineering (1932-38). He was president of Carnegie Institute (1939-55). Recipient of Levy Medal (1928), John Scott Award (1943), National Medal of Science (1963), President's Atomic Pioneer Award (1970), Dr. Bush developed transmission line transients, operational circuit analysis, gaseous construction apparatus and analytical devices and wrote two books, viz., *Principles of Electrical Engineering* and *Endless Horizons.*

R.K. DATTA

Cell biologist Dr. Mirsky is dead

DR. Alfred Ezra Mirsky, former professor of cell biology of New York's Rockefeller University, who found methods to isolate the genetic materials DNA, histones and nuclei of animal cells for scientific studies, died on June 19, 1974 in New York at the age of 73.

Born on October 17, 1900 young Mirsky was educated at Ethical Cultural School and Harvard College (graduating in 1922). He moved to Cambridge University as a National Science Foundation fellow for further studies in physiology and received a Ph.D. degree in 1925. Next year, he joined Rockefeller Institute of Medical Research, be-

(*Continued on page 554*)

MEDICAL NOTES

Homogenised milk responsible for coronary diseases

HIGH cholesterol level in the blood and the factors responsible for it such as the saturated fatty acids in the diet have long been considered responsible for the artereosclerotic diseases of the heart. But Dr. Kurt A. Oster, the Chief Cardiologist of the Park City Hospital, Bridgeport, U.S.A. recently reported in the 7th International Water Quality Symposium held in April, 1974, that the homogenised milk and not cholesterol is the fundamental cause of heart attacks. He contended that his research has shown that xanthine oxidase, an enzyme found in cow milk, is the cause of the disease. This enzyme attacks aldehydes—substances essential for maintaining the elasticity of the artery walls. The enzyme is contained in the fat globules of milk. When milk is homogenised, fat globules are broken up and the enzyme molecules are exposed. Homogenisation also breaks down the enzyme into small particles, which instead of being digested in the intestinal tract, enter the blood stream. Smaller particles, presumably still possessing the active centre of the enzyme, act on the aldehydes. Thus, it is the 'micronisation' of the enzyme that causes the trouble.

Commenting on his studies of death rates from heart diseases in various countries, Dr. Oster said that Finland has both the highest death rate from heart disease and the highest rate of milk consumption. The United States with the second highest death rate from the same disease, has relatively low milk intake. However, most milk in this country is homogenised, and homogenisation multiplies the biological availability of xanthine oxidase by at least 3.5. Though the Americans drink only 124 kg of milk per capita annually, homogenisation makes it equivalent to 429 kg per capita. Sweden and France have relatively low death rates from cardiovascular disease. Sweden has the second highest milk consumption in the world, but the milk is not homogenised in this country. France has the highest cheese consumption in the world. But in cheese, xanthine oxidase is present in larger particle size and is probably digested and not absorbed into the blood stream. The high saturated fatty acid content of milk and cheese consumed in these countries and their relatively low cardiovascular death rates certainly speak against the theory that high saturated fat intake causes coronary disease and the high incidence of heart attacks.

B. PAL

Cultivation of leprosy bacilli in mammals

WHILE leprosy is one of the public health hazards in many parts of the world, the biomedical studies of the causative agent, *Mycobacterium laprae*, could not progress much owing to the failure of these bacilli to grow easily in artificial media. Recently, Drs. E. E. Storrs, G. P. Walsh and H. P. Burchfield of Gulf South Research Institute of New Iberia, Louisiana and Dr. C.H. Binford of Armed Forces Institute of Pathology, Washington, D.C. developed leprosy in armadillos, small burrowing mammals of Texas and South and Central America, covered with bony plates, and obtained fairly good amounts of leprosy bacilli (*Science*, **183**, 851, 1974). According to their reports, eight of twenty armadillos (*Dasypus novemcinctus, L.*) developed severe lepromatous leprosy 3 to 3½ years after inoculation with viable *Mycobacterium leprae*. A total of 988 grams of lepromas containing an estimated 15 to 20 grams of leprosy bacilli were harvested from these animals. These investigators expressed the hope that the large amounts of material now available would permit in-depth studies of the biochemical and metabolic aspects of the leprosy bacilli, and that the animal model should make possible definitive studies on the immunology, chemotherapy, and epidemiology of leprosy.

BHAKTI DATTA

SCIENCE FOR THE YOUNG

What you should know about your TV antenna

AT last the 'Magic box' is with us to educate and entertain. Yes, I am talking about the television, a vital audio-visual media of the 20th century. Sometimes I wonder how many of us have ever thought about the working of TV. When we sit in our living room, engrossed in watching the live performance on our set, have we ever thought what makes these motion pictures appear before our eyes?

Here I am not going to deal with the whole system behind transmission and reception of television programme, I will restrict to the "wand" which helps work the "Magic box". By "wand" I mean the antenna (aerial) which plays an important role in helping your set give a lively and clear performance. Antennas on the roofs and terraces of buildings make a familiar sight in the cities of Delhi and Bombay and adjoining towns.

TV antennas are primarily known as 'Yagi' antennas named after the Japanese physicist Hidetsugu Yagi, who developed them. Although different types of antennas are in use in different countries for multichannel and coloured telecast, we are concerned here with the Yagi antenna which is presently being used in India. This antenna is most suitable for single-channel monochrome telecast.

The basic element of a "Yagi" antenna is a "folded dipole" (Fig. 1) having a characteristic impedance of 300 ohm (at which the formation of standing waves is prevented). This increased impedance, compared to 72 ohm impedance of other types of antennas, permits wider spacing to be used in the transmission line and gives a much wider bandpass. Besides the dipole, there are reflectors and directors. Usually, single reflector and single director are used in the construction of a simple, three element Yagi antenna (Fig. 2).

The dipole

The length of the dipole is one-half of the physical wavelength of the transmission. The energy waves from the transmitter are alternating at a certain frequency having a certain distance between energy peaks. This is actually the physical wavelength. We all know from the fundamental theory that a magnetic field cutting a conductor will induce a current in the conductor. Hence, to obtain the maximum amount of energy from the signal wave front so that the highest signal voltage is developed at the input of the TV receiver, the dipole (conductor) of appropriate length (as above) is used. A current is thus induced in the antenna when it obstructs the magnetic field of the signal.

Now, in order to increase the gain of the dipole parasitic elements are used. The name is derived from the fact that these additional elements are not connected directly to the transmission line but take their energy directly from the passing signal fields. There are two forms of parasitic elements: reflectors and directors. They differ in length and position only.

Reflectors and directors

Reflectors are usually longer than the dipole and are always mounted behind it, that is, opposite to the

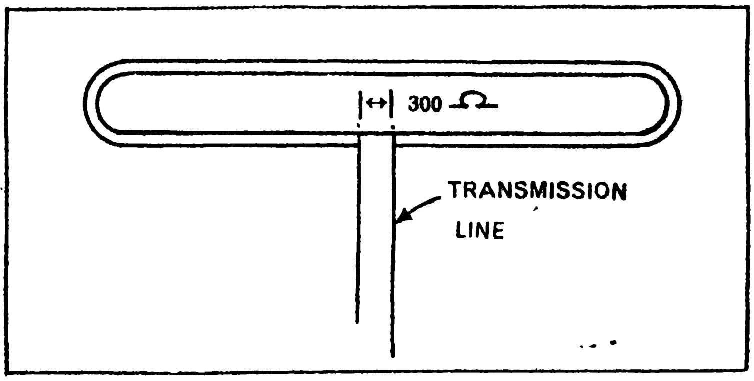

Fig. 1. Folded dipole

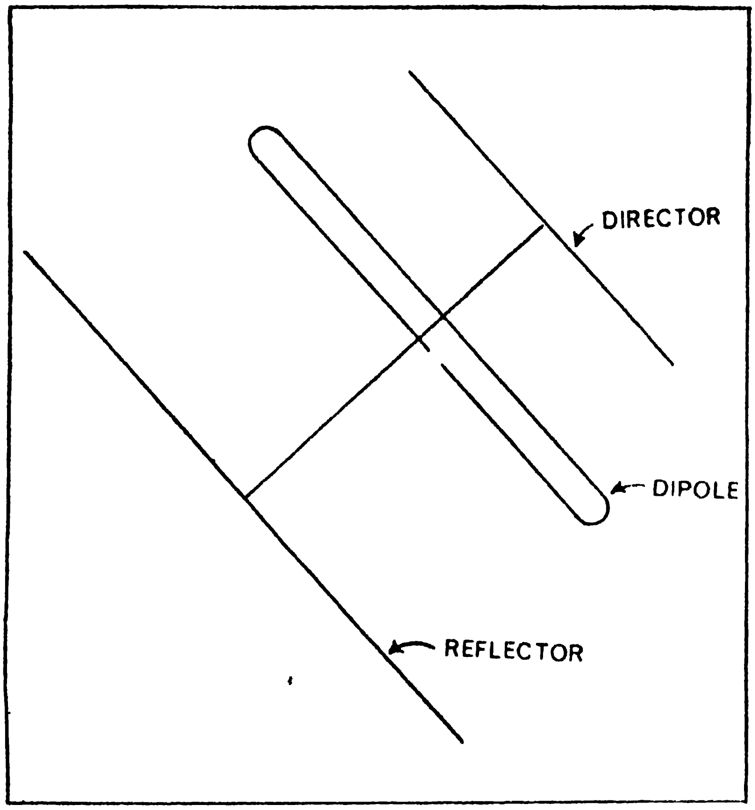

Fig. 2. Three element yagi antenna

Installation of antenna

The proper installation of antenna imparts maximum clarity to a set. The transmission line, that is, the wire running from the antenna to the receiving set, is the twin lead with 300 ohm impedance to match both the antenna and the receiver set. The TV antenna should be erected on a height that will ensure maximum clarity to the pictures. In practice, the erection is done at a height of 10 feet above the roof surface in order to reduce pattern deterioration.

After choosing the most suitable place, taking into consideration the appropriate height and avoidance of reflected signals (ghosts) from nearby buildings and other obstructions, the antenna is fixed to the mast which is clamped to the wall of the roof. It should be noted that the director should face the transmitting antenna transmitter. The actual spacing between them varies with the requirements of the design, but on average it is from 0.25 wavelengh to 0.15 wavelength. The function is always the same no matter what spacing is used. Fig. 3 shows a dipole antenna and its reflector.

The director is always mounted in front of the dipole (Fig. 4). Director's spacing varies just like that of reflector's but is usually very close to 0–1 wavelength. Both directors and reflectors help build up the current, thus increasing the gain of the antenna. The increase in gain is not usually too high, the major effect is the narrowing of the frontal-lobe. The addition of more directors (Fig. 5 a-b) increases the gain slightly, but narrows the frontal lobe still more. The narrowing of frontal lobe helps very much in eliminating ghosts (double images).

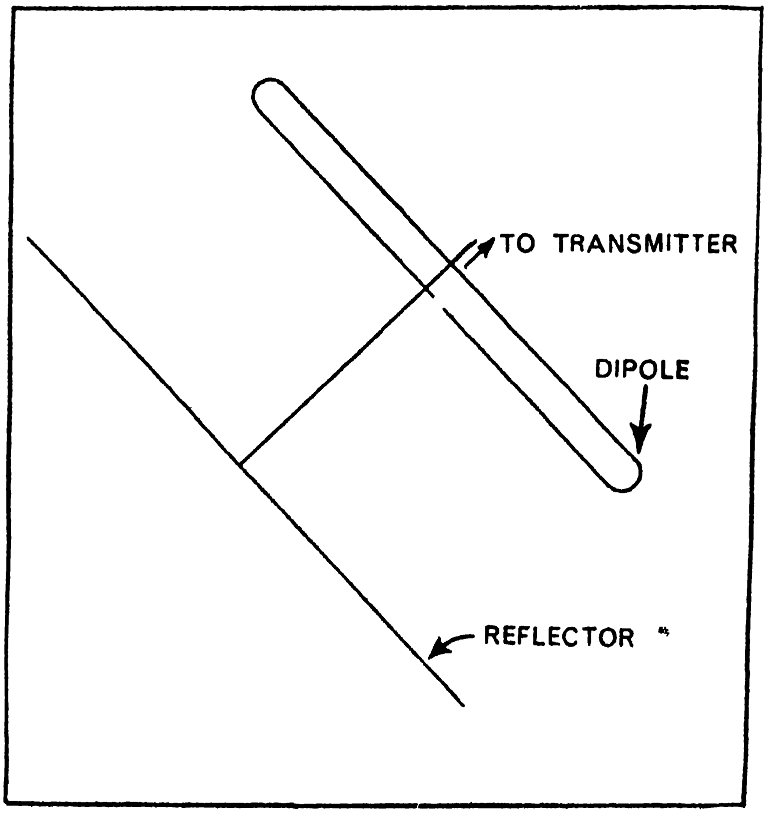

Fig. 3. Dipole antenna and its reflector

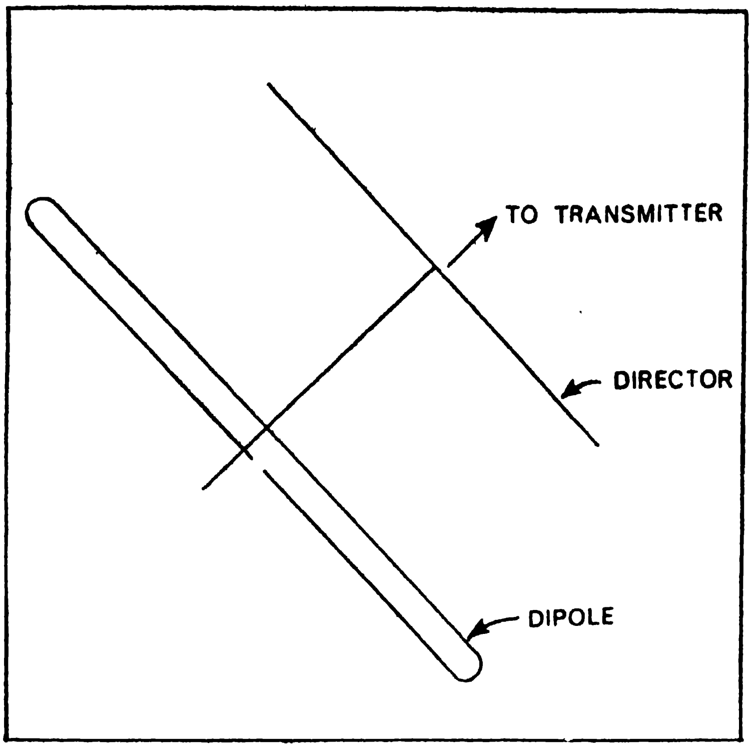

Fig. 4. Director in front of a dipole

and as far as posssible a clear line-of-sight should be maintained between the transmitting and receiving ends.

The feeder line used is the 300 ohm impedance unshielded twin lead. In order to minimise the losses this line should be kept away from all metal objects such as tin roofs, supporting masts, gutters, water tanks, etc. The losses occur since the capacity between the transmission line and the metallic objects may be sufficient to act like a low reactance path for signals, particularly at higher frequencies. The capacitive reactance has a greater shunting effect. It is, therefore, advisable not to tap the twin lead to the antenna-supporting mast. On fixing the twin lead to the antenna terminals, it should run down at as wide an angle as possible from the mast. As the line is brought to the receiver it should be given a 180° twist at about every metre of its length to reduce pick-up to about 30%. If the neighbourhood is considered to be noisy, it would be better to instal the line as far away from the noise source as possible.

Elimination of 'ghosts'

We are all familiar with the double images which occur on the right hand side on the screen. To eliminate or minimise these, we should know how these images originate and what precautions should be taken to eiminate them. These extra images in the TV picture are known as 'ghosts'. The ghost appears as a shadowing duplicate and to the right of the original image. It is caused by another signal reflected to the antenna by a tall building, mountain or any other obstruction. The added distance which this signal travels causes a slight delay in its arrival at the receiving antenna. The signal, therefore, appears on the screen to the right of the original image (Fig. 6).

The ghost appears on the right side because the direction of the scan is from left to right. Although ghosts can be caused by a severe mismatch on the transmission line, the major cause is a double signal. One signal is in a direct path from the transmitter, while the other is reflected from some object. The only cure lies in the antenna installation.

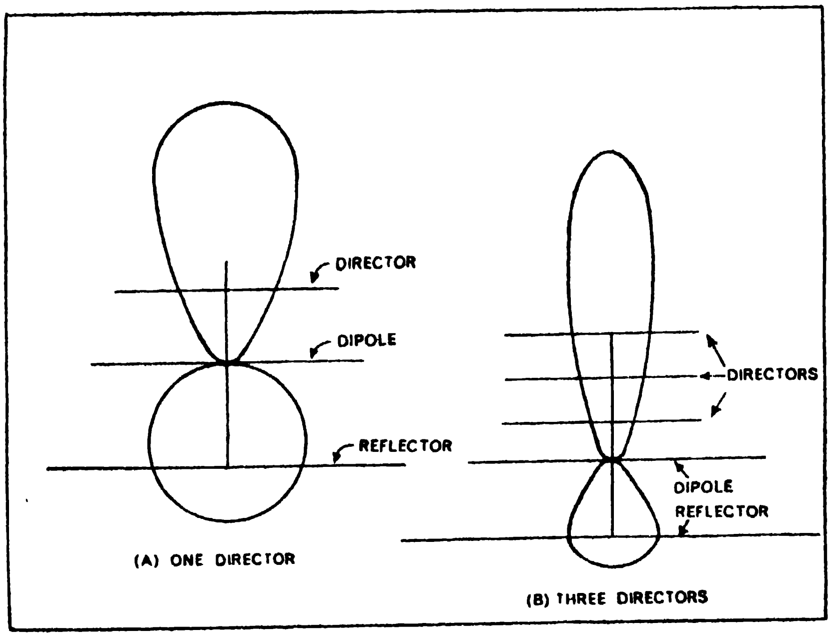

Fig. 5. Effect on response when directors are added to a dipole

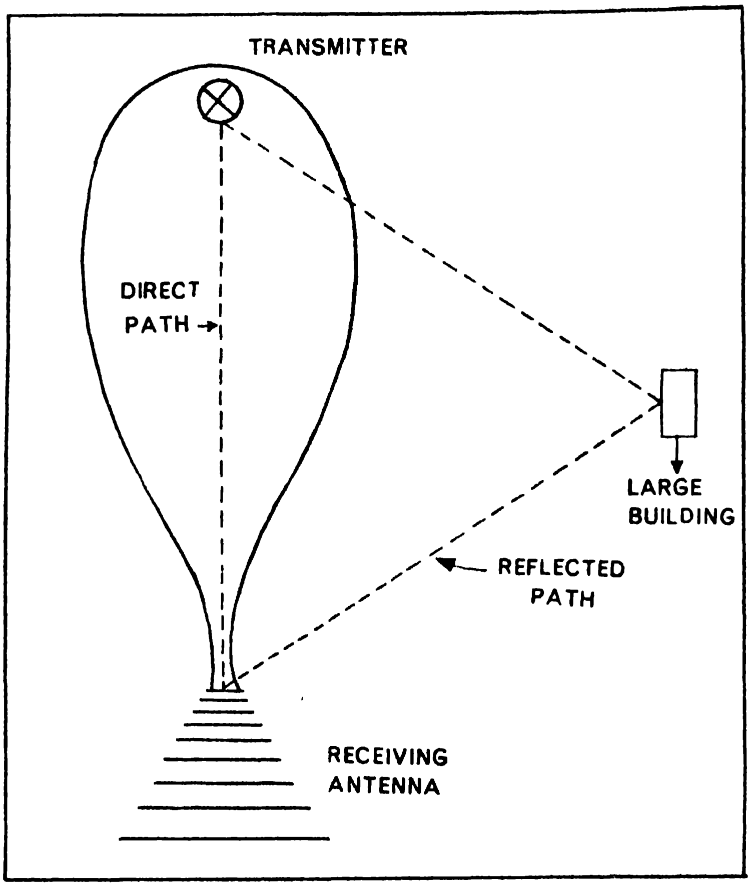

Fig. 7. Using an antenna with a sharp directional pattern to reduce ghost intensity

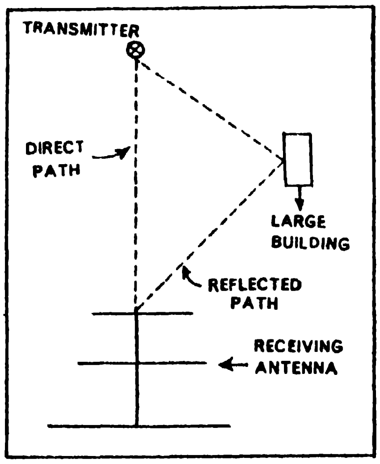

Fig. 6. Ghosts caused by an undesired signal bouncing off a building

Nothing can be done on the TV receiver to eliminate it.

One way to reduce 'ghosting' is to use sharply directioned antenna even in secondary or primary areas. These narrower antenna patterns, however, reduce the intensity of the ghost signal; at the same time the desired direct signal is often increased to the point where the problem is solved (Fig. 7). In extreme cases sheilding of the antenna becomes necessary. An actual screen, made of screen wire or small mesh chicken wire (a woven wire screening) is erected between the antenna and the undesired signal to reduce its intensity. This screen can be mounted on a light wooden frame and guyed in place. For better results, the height and width of the screen should average a little over one-half wavelength (or more) of the channel to be received. Also, the screen should be not less than one-half wavelenth from the antenna. However, before going into such method it is advisable to choose the best place on the roof, by trial, at different places and/or using directional antennas, i.e., antennas with more directors.

There is always a temptation to leave the excess twin lead at the back of the TV set in the form of a coil. This is done to move the set to another part of the room or even to the other room for convenience. Despite the convenience, the lead should never be coiled in this way. Adjacent turns of the twin lead come in close contact and upset the electrical balance between the two conductors.

Never allow the lead to swing. This may produce pulsating or unstable pictures as sufficient capacitance could be introduced across the line to cause electrical imbalance and reduce its signal carrying ability.

As such, the installation of the antenna should be done after considering such factors as wind, rain, snow, salt spray, and the effect of the surrounding objects. Other factors to be considered are operating temperature and such mechanical forces as shock and vibration. A properly installed antenna gives good performance at minimum cost.

BIRENDRA A. GUPTA

SCIENCE IN INDUSTRY

Ear microscope

THE Central Scientific Instruments Organisation (CSIO), Chandigarh, has designed and developed a monocular type ear microscope. The instrument consists essentially of an arrangement to illuminate the interior of the ear and a microscopic system to view the magnified image.

The illuminating arrangement consists of a light source (6V, 12W standard lamp) with stepped control for intensity variations. The semi-spherical surface posterior to the semi-circular filament of the lamp is silvered to provide a complete circular filament as an effective source of light. The radiations of the lamp, after passing through condenser, are reflected by plane and concave mirrors to form an intense circular light patch. The whole arrangement is located in the main body of the instrument.

An objective Porro's prism assembly and Ramsden's eye-piece (with iris diaphragm) form the viewing system of the instrument, providing an overall magnification of 6·3 ×. The object field/size, which can be varied from 2 to 8 mm for all positions of the eye-piece focusing movements, helps exclude the reflections from the speculum walls, thereby increasing the contrast of the image.

The complete instrument is provided with five specula of various sizes to be used with different age groups, and a transformer for the lamp supply.

The instrument is being used in medical institutes and hospitals and is required by most of the medical practitioners. It is useful for examining the inside of the ear for swellings, discharge, vascular tumours and defects of the tympanic membrane. All the materials and components used in the fabrication of the instrument are available indigenously. Any firm having a mechanical workshop capable of turning, milling, surface-finishing and fitting operations along with an optical workshop capable of manufacturing precision optical components like lenses and prisms can take up this process.

Cloth density tester

THE Central Scientific Instruments Organization (CSIO), Chandigarh has designed and developed a projection-type cloth density tester. Using this apparatus, the density of warp and weft yarns in single-weave cloth, not raised or filled, can be determined in a length of 50 mm or less.

The cloth specimen, adequately extended over the stage of the apparatus and fixed by clamps, is trans-illuminated on a surface (approx. 20×55 mm). The image of the illuminated surface is projected by a lens-and-mirror system on a screen in an exactly ten-fold magnification. The screen is provided with centimetre graduation in length of cm in the horizontal direction and 20 cm in the vertical direction. On the magnified image the number of yarns in the unit length can be easily counted by the naked eye. Two pointers, actuated by turning knobs, move along behind the screen to facilitate counting the number of yarns in both horizontal and vertical directions.

The aluminium alloy casting case of the apparatus houses the optical system that serves to trans-illuminate and project the image of the cloth under test. Th light source of the apparatus is a low-voltage high light intensity bulb, adjustable in all directions. The light from the lamp is collected by a concave mirror and by a compound condenser lens system into the opening of the horizontal object carrier stage. On the stage is attached a device by which the cloth strip can be moved to and fro for inspection at different places by rotating the two knobs provided above the trans-illuminated box. A coloured filter pocket is also fitted below the device, which can hold filter glass of required colour for viewing the sample in coloured light. The opening on the stage is covered with an easily removable glass plate.

The totally closed projecting camera is made of sheet iron, with the inside painted dull black. The projecting device is mounted on its front plate. The large plane mirror arranged inside the camera opposite the objective projects the image on the plastic screen arranged on the front plate of the camera. The pointers serving to facilitate yarn counting are movable along the graduations immediately behind the screen. The pointers can be shifted in both directions smoothly and without backlash by operating the turning knobs mounted on the front plate of camera. The transformer, reducing the mains voltage to the voltage of the projecting lamps, is also housed inside the camera.

The specifications of the cloth density tester are as follows:

Testing length (Max.) : 3.9 in. (50 mm)
Magnification ratio : 10×
Screen graduation : 0.500 mm each 10 mm
Transformer : 220-110 V/6V, 50-60 c/s, 30W
Dimensions (approx.) : 24.2.×28.3×19.3 in (61.6×72.0×49.0 cm)

The instrument is being used in textile-testing laboratories and research institutes working on the development of textiles. The present demand for the product is met by imports.

The performance of the instrument fabricated by CSIO has been found to be satisfactory. Any entrepreneur having the usual workshop facilities and optical workshop for the production of optical components like lenses and mirror could take up this process; it will be uneconomical for a new unit to start the industry as the product has presently limited demand.

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BOOK REVIEWS

MAN BENEATH THE SEA by Walter Penzias and M.W. Goodman, *John Wiley & Sons Inc.*, 605, Third Avenue, New York, N.Y. 10016, U.S.A., Pp. 847, $ 32.50.

PREHISTORIC man feared the ocean, approached it with great caution and worked on it or in it with uneasiness. Today, however, this fear has given way to boldness and a new attitude of adventure has dawned on him mainly through scientific and technological reasoning. The ocean has characteristics which are beneficial to mankind. Thus for example the ocean is a vast heat sink, a huge vat of soluble chemicals, and a buoyant medium for lifting massive weights.

Beginning at the shoreline the sea floor extends outward in a shallow terrace known as the Continental Shelf. This was an average slope of about 0.1 degree and a width from zero to nearly 1300 km. At depths from 1200 to 1900 m, a break occurs and then beyond lies the ocean basin floor at depths of 27000 to 60,000 m. Other than water, the principal components of sea water in descending order of concentration are chlorine, sodium, magnesium, calcium, potassium down to iron, silver and gold.

How can man explore these valuable minerals, how can he explore the living organisms of the ocean and how can he live underwater and undertake salvage work. The answers to all these questions are admirably given in this large and voluminous work covering 19 sections, each fairly self-contained and complete. The authors begin with an interesting digress on the technical history of diving dating back around 1600 A.D. down to the historic Pearl Harbour incident. The remaining 15 chapters which form the bulk of the text describe in detail diving systems, life support systems, underwater breathing apparatus, and dress. Undersea work is now being performed more and more by submersibles—tiny or medium sized vessels built for carrying out a number of special functions at depths upto 60,000 m like "Deepstar—20,000". These submersibles are described with detailed specifications, photographs and drawings and cover all the world's undersea vessels built so far. In addition, the authors cover in several chapters the communication, navigation and sonar methods gas storage and mixing systems, pressure vessels and hatches, underwater electrical connections, umbilicals, power propulsion and physiological effects. The ocean environment is only briefly surveyed as other excellent publications are available on that subject. The last chapter rightly goes into a little fantasy, when the authors take a peep into the future. They visualise a colony of investigators undertaking deep sea work, normal transport flowing at the sea bottom, and even a city-complex built on the bottom of the sea, with nuclear reactors as the key element in their functioning.

This is a very up-to-date and authoritative work on all aspects of diving vessels, fully illustrated with extensive references. Its only drawback is its price (nearly Rs. 250/-) which is beyond the purse of any individual, though fully justifiable in comparison to its valuable contents.

S.K. Ghaswala

FUNDAMENTAL GENETICS OF STREPTOMYCETES by J. Horvath, *Akademiai Kiado*, Budapest, Hungary, 1968, Pp. 119, Rs. 37.00.

THIS book would prove very useful to those engaged in the field of antibiotics of streptomyces origin, especially, if they are interested in developing high yielding antibiotic strains through genetical engineering. The book is divided in eight chapters. Chapter I deals with the materials and methods wherein a number of culture media and general requirements for investigations with streptomycetes have been mentioned. Chapter II deals with the variability in streptomycetes where it is emphasised that heterokaryosis and nuclear fusion are the main causes of variability in this group of organisms. Chapter III describes the existence of dauermodification in streptomycetes where following strong depression, the increased antibiotic production returns to its initial level. Chapter IV discusses the occurrence of spontaneous mutations in streptomycetes as well as induction of mutations through different physical and chemical mutagenic agents. Chapters V and VI describe the process of transformation and transduction in streptomyces, respectively. In Chapter VII the studies of heterokaryosis and recombination of auxotrophs have been discussed. This is a field where considerable work has been done by many scientific investigators. Chapter VIII deals with heterokaryosis and nuclear fusion among strains. There is an excellent bibliography at the end where research work done uptil 1966 has been enlisted. The book will not only be useful to scientists engaged in streptomyces research but also is a good general reading for any person interested in genetics of microorganisms.

Ajit K. Mishra

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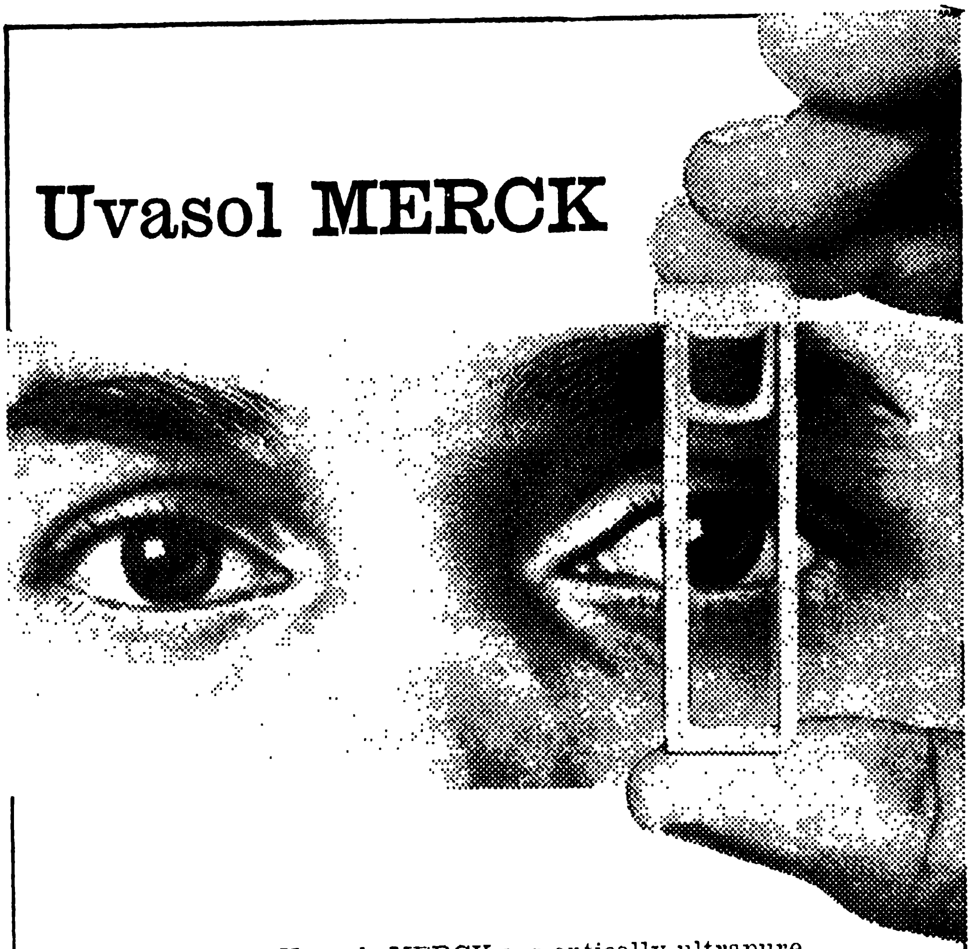

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